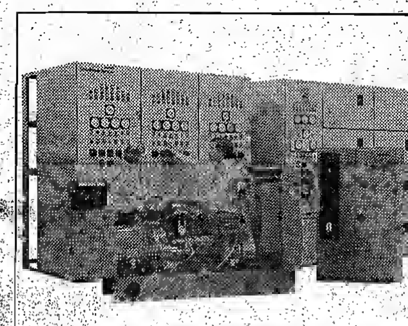
Technical Bulletin



Installation Information

for
Liquid Cooled GenSets

1/85 **T-030**

Safety Precautions

The following symbols in this manual signal potentially dangerous conditions to the operator or equipment. Read this manual carefully. Know when these conditions can exist. Then, take necessary steps to protect personnel as well as equipment.

Read your manual and become thoroughly acquainted with it and your equipment before you start your unit. These recommendations and the following safety precautions are for your protection.

Fuels, electrical equipment, batteries, exhaust gases and moving parts present potential hazards that could result in serious, personal injury. Take care in following these recommended procedures.

⚠DANGER ***This symbol if used warns of immediate hazards which will result in severe personal injury or death.***

⚠WARNING ***This symbol refers to a hazard or unsafe practice which can result in severe personal injury or death.***

⚠CAUTION ***This symbol refers to a hazard or unsafe practice which can result in personal injury or product or property damage.***

General

- Keep your electric generating set and the surrounding area clean and free from obstructions. Remove any debris from set and keep the floor clean and dry.
- Provide appropriate fire extinguishers and install them in convenient locations. Consult your local fire department for the correct type of extinguisher to use. Do not use foam on electrical fires. Use extinguisher rated ABC by NFPA.
- Make sure that all fasteners on the generating set are secure. Tighten supports and clamps, keep guards in position over fans, driving belts, etc.
- Do not wear loose clothing in the vicinity of moving parts, or jewelry while working on electrical equipment. Loose clothing and jewelry can become caught in moving parts. Jewelry can short out electrical contacts; cause shock or burning.
- If adjustment *must* be made while the unit is running, use extreme caution around hot manifolds, moving parts, etc.
- Do not work on this equipment when mentally or physically fatigued.
- Coolants under pressure have a higher boiling point than water. DO NOT open a radiator or heat exchanger pressure cap while the engine is running. Bleed the system pressure first.

Protect Against Moving Parts

- Keep your hands away from moving parts.
- Before starting work on the generator set, disconnect batteries. This will prevent starting the set accidentally.

Fuel System

- DO NOT fill fuel tanks while engine is running, unless tanks are outside engine compartment. Fuel contact with hot engine or exhaust is a potential fire hazard.
- DO NOT SMOKE OR USE AN OPEN FLAME in the vicinity of the generator set or fuel tank. Internal combustion engine fuels are highly flammable.
- Fuel lines must be adequately secured and free from leaks. Piping at the engine should be approved flexible line. Do not use copper piping on flexible lines as copper will work harden and become brittle.
- Be sure all fuel supplies have a positive shutoff valve.

Guard Against Electric Shock

- Remove electric power before removing protective shields or touching electrical equipment. Use rubber insulative mats placed on dry wood platforms over floors that are metal or concrete when around electrical equipment. Do not wear damp clothing (particularly wet shoes) or allow skin surfaces to be damp when handling electrical equipment.
- Use extreme caution when working on electrical components. High voltages cause injury or death. DO NOT tamper with interlocks.
- Follow all state and local electrical codes. Have all electrical installations performed by a qualified licensed electrician. Tag open switches.
- DO NOT SMOKE while servicing batteries. Lead acid batteries emit a highly explosive hydrogen gas that can be ignited by electrical arcing or by smoking.

Exhaust Gases Are Toxic

- Provide an adequate exhaust system to properly expel discharged gases. Inspect exhaust system daily for leaks per the maintenance schedule. Ensure that exhaust manifolds are secure and not warped. Do not use exhaust gases to heat a compartment.
- Be sure the unit is well ventilated.

Keep the Unit and Surrounding Area Clean

- Make sure that oily rags are not left on or near the engine.
- Remove all oil deposits. Remove all unnecessary grease and oil from the unit. Accumulated grease and oil can cause overheating and subsequent engine damage and may present a potential fire hazard.

SCOPE

This bulletin presents installation information for liquid cooled GenSets. The bulletin consists of detailed safety precautions, mounting methods, ventilation, cooling systems, fuel systems, exhaust systems, electrical systems, and typical installations. Also included are a glossary of terms, a standards index, and installation checklist, and cranking and running checks.

Onan products appear on the world market. The following terms, both English and SI Metric units, are used.

Term	English	Multiplier	SI Metric
Dimensions	inch (in.)	25.4	millimeter (mm)
	inch (in.)	0.0254	metre (m)
	square inch (in.^{2})	6.451	square metre (m^2)
Pressure	pounds per square inch (psi)	6.894	kilopascals (kPa)
	inches of water (H_20)	0.249	kilopascals (kPa)
	inches of mercury (Hg)	3.384	kilopascals (kPa)
	foot pounds (ft-lb)	1.356	Newton metre (N•m)
Density	pounds per cubic foot (lb^3)	1.602	kilograms/metre cubed (Kg/m^3)
Flow Rate	cubic feet per minute (cfm)	35.31	metre cubed per minute (m^3/min)
Mass (Weight)	pounds (lb)	0.4536	kilogram (kg)
Volume (Liquid)	gallon (gal)	3.7852	litre (L)
	Gal/Min.	3.7852	litre/Min.
Power	horsepower (HP)	7.46	kilowatt (kw)
Energy	British Thermal Unit (BTU)	1055.	Joules (J)
Temperature	Fahrenheit (F)	(°F-32) x 5/9	Celsius (C)
Frequency	cycles per second (cps)	None	hertz (Hz)

The customary unit of horsepower (HP) becomes kilowatts (kW) when converted to SI metric units. Do not confuse this kW rating with the kW rating of generators or motors which is always lower due to losses inherent with any electrical induction device.

Table of Contents

Table of Contents (Continued)

Table of Contents (Continued)

LIST OF FIGURES

List of Tables

Mounting

LOCATION

Generator set location is decided chiefly by related systems such as ventilation, wiring, fuel, and exhaust. Provide a location away from extreme ambient temperatures, protecting the generator set from adverse weather conditions, yet near as possible to the main power fuse box.

Plan for adequate access to the generator set for service and repair with lighting facilities around the unit. Wood floors should be covered with sheet metal extending 12 inches (305 mm) beyond the extremeties of the generator set.

GROUND LOADING

A proper mounting foundation must be calculated based on the total weight of the GenSet (including coolant, fuel and oil), together with the structure of the ground or subfloor loading.

WEIGHTS

Liquid	Lb/U.S. gal (kg)	Specific Gravity
Coolant water	8.3 (3.77)	1
Lube Oil	7.6 (3.45)	0.916
Diesel Fuel	7.1 (3.22)	0.855

The ground or subfloor supporting the foundation must carry the total weight. Ground or subfloor loading is determined by the type of surface material. Bearing load capabilities of specific materials are defined in engineering manuals relative to foundation design.

TYPICAL GROUND LOAD CAPABILITY

Surface Material	Safe Bearing Load psi (kPa)
Rock, Hardpan	70 (482)
Hard Clay, Gravel and Coarse Sand	56 (386)
Loose Medium Sand and Medium Clay	28 (193)
Loose Fine Sand	14 (96.4)
Soft Clay	0-14 (0-96.4)

Foundations on firm level soil, rock, hard clay or gravel provides satisfactory support with minimal footings. Foundations on fine clay, loose sand or soft clay are not stable enough under dynamic loads. In addition, larger foundations with deeper footings are required. Foundation footings in either case aid in the prevention of foundation movement.

Installations within buildings on subfloors must consider the load bearing pressure (pounds per square inch/kilo Pascals) of the mounting surface. Coordinate this type of installation with the maintenance staff or with the building drawings.

The area of load bearing support is adjusted to accommodate surface material. To determine pressure (P) exerted by the GenSet, divide the total weight (W) by the total surface area (A) of the rails, pads, or vibration mounts (see Figures 3 and 4). Use the following formula:

$$P = \frac{W}{A}$$

$$P\ (\text{psi/kPa}) = \frac{W\ (\text{Lb/kg})}{A\ (\text{In.}^2/\text{m}^2)}$$

Where: P = Pressure in pounds per square inch/kilo Pascals (psi/kPa)
W = Weight in pounds/kilograms (lb/kg)
A = Area in square inches/square metres (In. ²/m²)

Pressure imposed by the total GenSet weight must be less than the load carrying capacity of the surface material(s). When GenSet supporting rails, pads, or vibration mounts have insufficient bearing areas, floatation pads can be used to distribute the weight. Seasonal and weather changes adversely affect mounting surface materials. Consideration must be provided for surface material changes due to freezing and thawing. To prevent foundation movement caused by seasonal changes, extend foundation footings below the frost line.

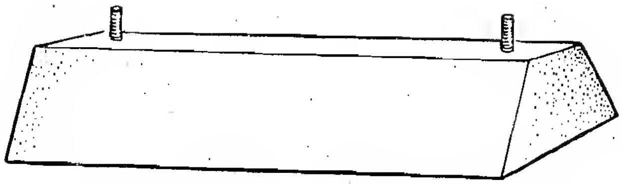


FIGURE 1. TYPICAL MOUNTING FOUNDATION

MOUNTING

Mount and secure the GenSet on a substantial and level base. A raised foundation will facilitate service and repair.

Foundations for small units can be concrete with anchored mounting bolts as shown in Figure 1 (steel beam sections make an acceptable alternate). Figure 2 shows a recommended foundation for gas or gasoline units of 100 kW and larger, or diesel units of 60 kW and larger. Bolt the generator set to the base to prevent unit movement during operation. Outline drawings with mounting locations and dimensions are available for all Onan GenSets.

Many basic concrete foundations are applicable for GenSets. The foundation for a particular installation depends on factors previously specified together with the limitations imposed by the location, application and local codes.

Massive concrete foundations are not required for modern multicylinder medium speed GenSets. Observe the following guide lines and formula to prevent over building the foundation to minimize overloading the surface material or building subfloor.

When effective vibration isolation equipment is used, the depth of foundation concrete is that required for structural support of the static load. For those installations not using isolation equipment, dynamic loads require that the foundation concrete should support 125% of the GenSet weight.

Calculate the depth of the foundation to equal the weight of the GenSet using the following formula:

$$FD = \frac{W}{D \times B \times L}$$

$$FD\ (Ft/m) = \frac{W\ (Lb/kg)}{D\ (pcf/kg/m^3) \times B\ (Ft./m) \times L\ (Ft./m)}$$

Where:

	FD* =	Foundation Depth in feet/metre (Ft./m)
	W =	Total GenSet Weight in pounds/kilograms (lb/kg)
	D =	Density of concrete in pounds per cubic foot/ kilograms/metre cubed (pcf 150/2403 kg/m³)**
	B =	Foundation width in feet/metre (Ft./m)
	L =	Foundation length in feet/metre (Ft./m)
	* =	An additional 25% without vibration isolating equipment
	** =	Use the values pcf 150 or 2403 kg/m³.

A typical foundation concrete mixture by volume is 1:2:3 of cement, sand, aggregate, with a maximum four (4) inch (101.6 mm) slump and 28-day compressive strength of 2500 psi (173 kPa).

Those installations requiring foundation reinforcement should use steel wire mesh (No. 8 gauge) or equivalent, horizontally placed on six (6) inch (152.4 mm) centers. Alternately, use steel reinforcing bars (No. 6 gauge) or equivalent, horizontally placed on 12 inches (305 mm) centers. Steel wire mesh or steel bars should be below the foundation surface a minimum of three (3) inches (76 mm).

After bolting down units 400 kW and larger, the generator mounting feet must be reshimmed to provide correct generator alignment. See the operator's manual for details.

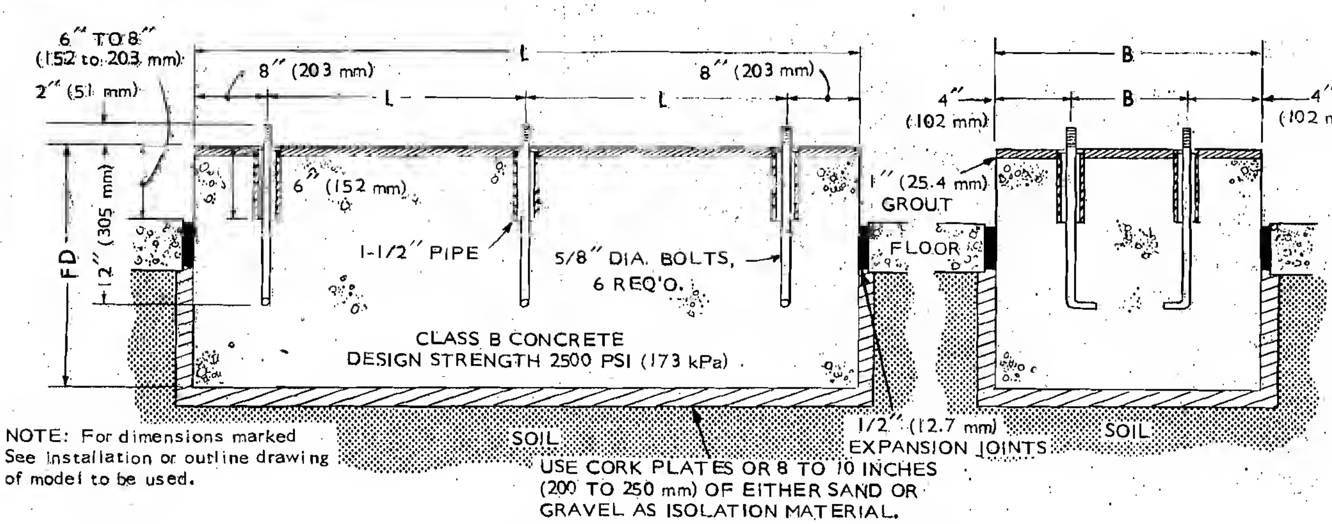


FIGURE 2. POURED CONCRETE FOUNDATION

VIBRATION CONTROL

GenSets up through 150 kW include integral rubber vibration isolators which provide 75 to 85% vibration attenuation. Spring type (Figure 3) or pad type (Figure 4) isolators can be used with larger generator sets to achieve similar results. High deflection spring type isolators can be used with any GenSet to achieve 95 to 98% vibration attenuation for critical installations.

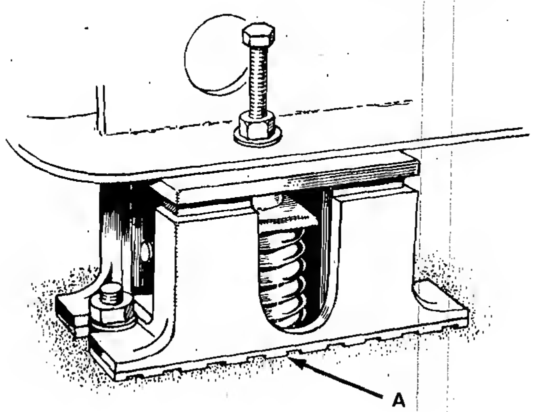


FIGURE 3. OPTIONAL SPRING TYPE VIBRATION ISOLATOR

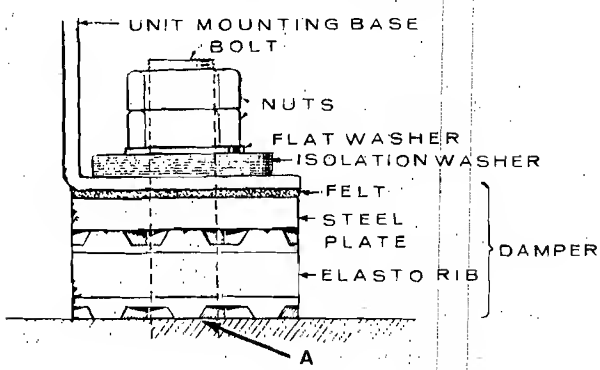


FIGURE 4. PAD TYPE VIBRATION ISOLATOR

NOISE CONTROL

You can attenuate exhaust noise by using proper mufflers. To attenuate other noises, use line-of-sight barriers, total acoustical enclosures, sound attenuating duct treatment, or install the GenSets away from critical areas. Onan does not supply acoustical enclosures, but there are companies which supply such equipment.

Equipment	Sound Level Reduction dB (A) (Approximate)
None	0
Vibration Isolators	2
Baffle (Single Wall Barrier)	5
Absorption Material (Walls and Ceiling)	5
Rigid Sealed Enclosure (Walls and Ceiling)	15-20
Rigid Sealed Enclosure (Walls and Ceiling) and Vibration Isolators	25-30
Rigid Sealed Enclosure (Walls and Ceiling), Vibration Isolators and Absorption Material (Walls and Ceiling)	35-40
Double Walled Rigid Sealed Enclosure (Walls and Ceiling), Vibration Isolators and Absoprtion Material (Walls and Ceiling)	60-80

VENTILATION

A ventilation system must function to provide sufficient air intake to satisfy the requirements of engine combustion and cooling together with air circulation in the equipment room. Engine radiator and auxiliary fans, together with vents and ducts employing dampers, provide air intake and air venting.

Ventilation systems are based on the presence or absence of a GenSet mounted radiator and fan. GenSet mounted radiator and fan are sized to provide adequate airflow to remove all engine, generator and a few feet of uninsulated exhaust pipe rejected heat. Refer to Table 1 Heat Loss from Uninsulated Exhaust Pipe and Mufflers. GenSet radiator cooling system airflow, radiator area and coolant capacity are listed in Product Data Sheets. Restrictive ducting or other than GenSet heat sources (paralleling and switching equipments) requires the use of auxiliary fans to increase airflow.

ENGINE AIR INTAKE

The engine must be supplied with the proper air to ensure maximum combustion. This air must be clean and at the proper temperature. Insufficient air causes carbon buildup and can cause engine damage. A high intake air temperature will reduce engine horsepower while a low intake air temperature will reduce the efficiency of the engine. The desirable intake air temperature for most GenSets is between 60° F (15.6 C°) and 90°F (32.2 C°).

EQUIPMENT ROOM AIR

The equipment room in addition to the GenSet(s) exhaust pipe and muffler(s) usually contains paralleling and switching equipments that radiate heat. This heat must be taken into consideration when planning the ventilation system. If circulation can not be provided by natural air flow, an auxiliary fan must be used.

REQUIRED COOLING AIR

To determine the air needed to remove GenSet heat reduction in an installation enclosure or room with a remote radiator, or heat exchanger cooled GenSets, use the following formula.

English $V = \dfrac{Q}{1.08 \text{ Delta T}}$ Metric $V = \dfrac{Q}{0.07242 \text{ Delta T}}$

Where: V is air in cubic feet/min (cubic metres/min) needed to remove the heat;
Q is heat in Btu/Hr (MJ/Hr) to be removed;
Delta T is the permissible room temperature rise in degrees Fahrenheit (Centigrade).

Example: Heat rejection to the room, determined from the Product Data sheet for the GenSet, is 115,500 Btu/Hr. If the allowable temperature rise is 20 degrees, the required cooling air V is:

$$V = \frac{115{,}500}{1.08\ (20)}$$

$$V = \frac{115{,}500}{21.6}$$

V= 5,347 cubic feet/min

VENTS AND DUCTS

Vents and ducts, shown in Figure 5, provide the means for properly ventilating the equipment room. Inlet vents provide the path for fresh airflow and the outlet vents provide the outlet for exhaust airflow to and from the equipment room. The size of these vents is determined by the required air intake, allowable total pressure drop and the type of cooling system being used. Remote radiator and heat exchanger systems require smaller vent sizes than GenSet mounted radiator systems.

If dampers or louvers are used with vents and ducts, vent sizes must be increased to compensate for airflow restriction. Usually, the vent size is increased about 1/4 to 1/2 times greater than without a damper or louver system.

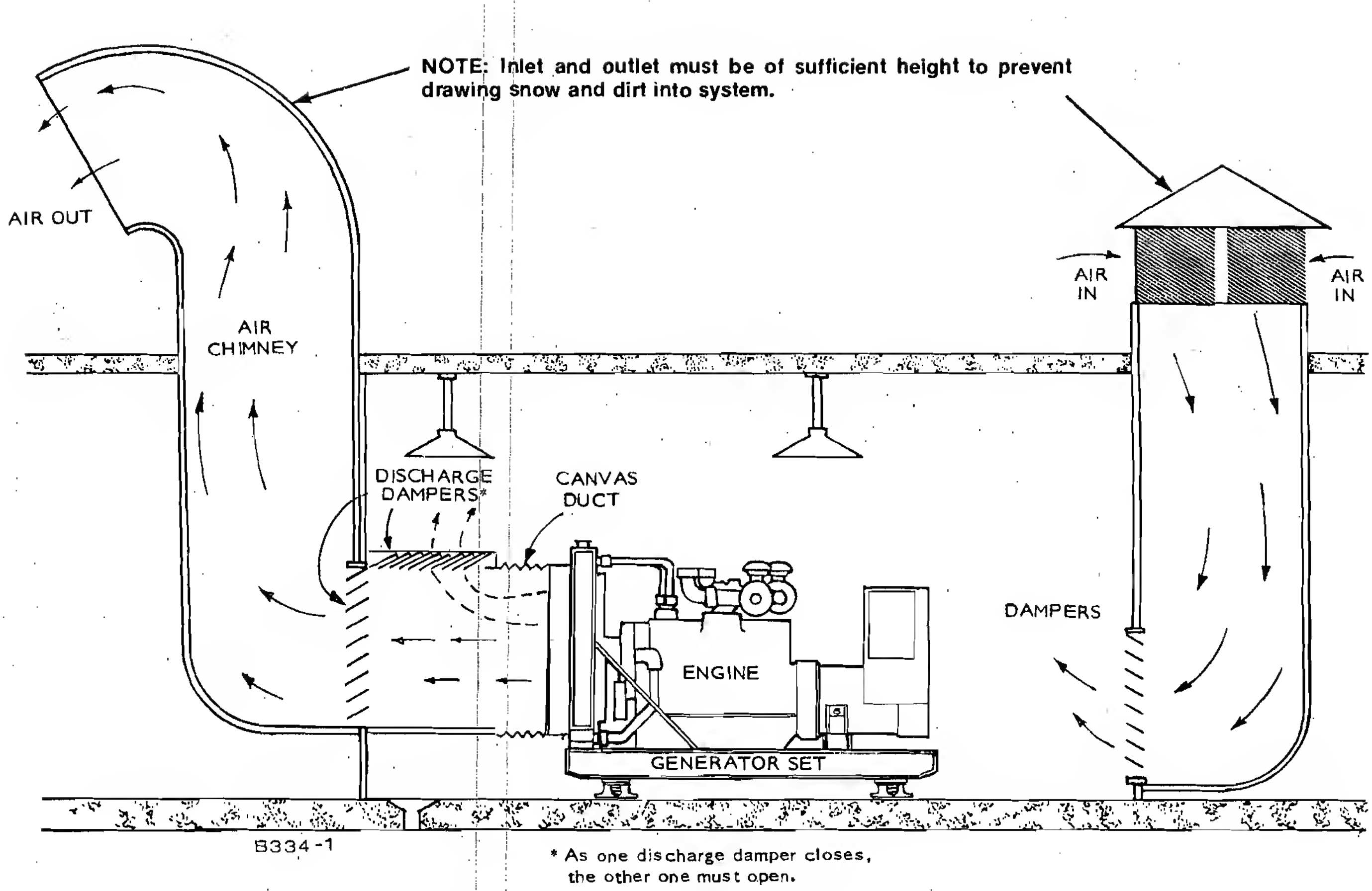


FIGURE 5. TYPICAL DUCT INSTALLATION WITH ROOFTOP AIR INLET AND OUTLET AND DAMPERS FOR AIRFLOW

Inlet Vents

Inlet vents, usually larger than outlet vents, assure enough airflow is available to enter the equipment room. Inlets should be located on an outside wall or roof, directly behind the GenSet.

To determine the size of inlet vents, the airflow requirements needed to control the room temperature must be calculated. These calculations must take into consideration the GenSet heat rejection, exhaust system, any other equipment in the room, and the total pressure drop.

Heat radiated from the GenSet is stated on the Product Data Sheets. Exhaust system radiated heat is dependent on the length of exhaust pipe, size of muffler(s), and whether mufflers are insulated and located in the equipment room.

Outlet Vents

Outlet vents removed heated air from the equipment room to the outside. If a GenSet mounted radiator is used, the outlet vent must be located directly in front of the radiator. Size the outlet vent to meet the requirements of the cooling system. Engines cooled by remote radiators require outlet vents large enough to remove most of the air flowing through the equipment room. In some installations the assistance of an auxiliary fan may be required.

DUCTS

Ducts serve to prevent problems with recirculating cooling airflow. Two (2) types of recirculating problems occur, radiator and outlet/inlet vents recirculating airflow.

Refer to the ASHRAE Handbook of Air Conditioning, Heating and Ventilation, Section 2 for duct design data.

The use of flexible canvas duct between the radiator and outlet vent prevents this type of recirculation problem.

⚠WARNING ***Inhaling exhaust fume gases can result in serious injury or death to personnel. Do Not terminate the exhaust system in the duct.***

Locating the outlet vent higher in elevation and widely separated from the inlet vent prevents this type of recirculating problem. The duct free area must be as large as the exposed area of the radiator. If bends in the ducts are required, minimize restrictions.

AUXILIARY VENTILATING FANS

Some installations may require an auxiliary ventilating fan to increase airflow in order to reduce the temperature in the equipment room. Locate auxiliary fans (thermostat controlled) as high up as possible in the room. Larger inlet vents must be used when using an auxiliary fan.

Auxiliary ventilating fans require an electric motor compatible with the system power source. The voltage, frequency and horsepower of the required motor must be specified. Horsepower will be dependent upon the fan size based on airflow (cfm) requirements.

DAMPERS

Damper or louvers protect the GenSet and equipment room from the outside environment. Their operation of opening and closing should be controlled by the operation of the GenSet(s). There are four main categories of dampers:

1. Automatic - The dampers open any time the GenSet runs.
2. Manual - This damper is opened and closed manually.
3. Thermostatically controlled - This damper is controlled by thermostats which sense either water or air outlet temperatures.
4. Fixed - This damper is permanently open and can not be closed.

In cooler climates, movable or discharge dampers are used. These dampers allow the heated air to be recirculated back to the equipment room. This enables the equipment room to be heated while the GenSet engine is still cold, increasing the engine efficiency.

Cooling System

Liquid cooled engines use the pasages in the engine block cylinder head, intercoolers and sometimes jackets around the exhaust manifolds for coolant flow. The coolant (water, water treatment, anti-freeze), etc.) is pumped under pressure throughout engine passages and jackets. On the route from the engine block inlet to the outlet, the coolant absorbs heat from the engine. This heated coolant is either cooled by a radiator or heat exchanger. Liquid coolant systems consist of local or remote fan cooled radiators or water cooled heat exchangers.

⚠CAUTION ***Some High Engine Temperature Cutoff switches will shutdown an overheated engine only when the coolant level is high enough to physically contact the switch. Too low a level of coolant allows an engine to overheat without the protection of the switch, thereby causing severe damage to the engine.***

OPERATING PRINCIPLES

This manual describes two methods of cooling engines using liquid coolant. In addition, the reasons for using coolant heaters are described.

Circulating the coolant from the engine through a fan cooled radiator and back to the engine, is the first method. Circulating the coolant from the engine through a water cooled heat exchanger and back to the engine is a second method.

While radiators are self contained units, heat exchangers normally require a tank, cooling tower or drain to dump the cooling water.

For unattended standby applications, coolant heaters may be required. Dependent upon the environment, coolant heaters with thermostats will improve engine starting and load acceptance capabilities, and increase engine life.

Radiator Cooling

A radiator consists of multiple coolant tubes with heat radiating fins. The tubes provide the coolant path while the fins provide the surface area to radiate (transfer) heat from the coolant to the air stream (atmosphere). The air stream is produced by an engine or electric motor operated pusher-type radiator fan.

Mounted Radiator Cooling

⚠CAUTION ***GenSets using system corrosion resistors, Do Not use anti-freeze solutions with an anti-leak formula. An anti-leak formula will clog the coolant system components.***

Mounted radiators are installed on the base of the GenSet in front of the engine. The mounted radiator with a pusher-type radiator fan is the most economical method of cooling an engine. The air stream drawn over the engine by the fan is pushed through the radiator. This action provides surface cooling for the engine together with cooling of the engine coolant. Radiator and fan cooling is independent of interruptible utility supplied cooling water. In addition, coolant can be treated with rust inhibitors, anti-freeze, etc. Radiator cooling does require large ventilation vents and ducts.

Remote Radiator Cooling

Some installations require the radiator and fan mounted separately from the GenSet. While these systems offer more versatility, require less power room ventilation, and can use low-noise fans, these systems are more expensive in original cost than the other cooling systems. There are two categories of remote radiator designs (see *"Remote Radiator System Designs"*).

REMOTE RADIATOR SYSTEM DESIGNS

General Information

Pipe Sizing: When water flow is produced by the engine-driven water pump, total piping pressure drop must not exceed the engine manufacturers recommendation. If water flow is assisted by an auxiliary pump, piping pressure drop must be matched to pump capacity at desired water flow.

Remote Radiator Airflow: Remote radiators are designed for installations where no external airflow restrictions occur. If the remote radiator will ventilate a room, has any ducting, or its airflow is opposed by prevailing winds, the cooling capacity is reduced.

Remote Radiator Fan Motor

A remote radiator fan requires an electric motor compatible with the emergency power source. The voltage, frequency and horsepower of the required motor must be specified. Horsepower will be dependent upon the fan size based on air flow (cfm) requirements.

Deaeration

⚠CAUTION ***Radiator top or surge tanks must be located at the highest point in the system. High sections of unvented plumbing can cause air pockets which prevent cooling flow, resulting in engine overheating.***

Deaeration is the function of removing air from a liquid. Because air enters the cooling system, radiators must be vented. GenSet mounted and Short Remote radiators are vented through pressurized vent caps. Other installations require surge or top tanks with relief caps or valves. These tanks must have adequate volume so the engine inlet and outlet are located below the normal running coolant level, and an expansion air space.

⚠CAUTION ***The 40 foot (12.2 m) head pressure limit is the maximum allowable for a single Onan pump and tank system. If vertical distance creates greater head pressures, add secondary pumps or higher capacity pumps and tanks. This type of system requires a qualified consulting engineer with hydraulic cooling system design experience.***

Auxillary Pumps: The auxiliary pumps listed show the pumping capacity with approximately a 40-foot (12.2 m) head pressure. 3*(See Table 2 on Auxiliary Water Pumps.)*

Proper pump and motor selection is based on pump duty, capacity and head loss. A restriction or gate valve may be required on the auxiliary pump outlet to maintain pump pressure head loading and prevent motor overloading. Check proper pump operating and loading by operating the entire system. If coolant is discharged from the radiator overflow or at the vent system outlet, slowly close the gate valve or increase the restriction in the pump until the overflow action stops. Do not increase pump outlet loading so much that the pump overloads.

Electrical: Make connections of fans and auxiliary pumps to the GenSet power distribution panel so the fans and pumps operate whenever the GenSet operates. Special voltages are available.

Flexible Hoses: Install flexible hoses to isolate vibration at the engine and radiator water inlets and outlets.

Drain Valve: At the lowest point in the cooling system, install a drain valve for cleaning and flushing.

Heat Rejection: The heat rejection to coolant figures of Onan GenSets are listed in specifications gasoline and diesel powered systems.

Radiator Selection

Remote radiators for Onan GenSets are available from the Perfex Corporation, Milwaukee, Wisconsin; or, from Young Radiator Company, Racine, Wisconsin. Sizing is determined by the GenSet specification.

Consider radiator noise levels for each installation. Lower noise levels require lower speed fans but also require larger radiators.

Radiator sizes are based on 190°F (88°C) engine water outlet temperatures. Maximum operating radiator inlet temperatures are rated at a maximum altitude of 1200 feet (366 m) above sea level. Operating at higher altitudes requires derating the cooling capacity 2 percent for each 1000 feet (305 m) above the first 1200 feet (366 m).

Remote Mounted Radiators

Remote radiators can be located a horizontal or a vertical distance, from an engine. The horizontal distance is limited by the capability of the engine driven water pump and the maximum external Friction Head pressure. The vertical distance is limited to the maximum Static Head pressure which can be imposed on coolant system gaskets and seals without leakage of coolant from coolant system components. The Friction and Static Head pressures of each GenSet are included in their Product Data Sheet.

Horizontal Location

Coolant system pipe must be free of obstructions (debris) and excessive bends (elbows, tees or couplings). Pipe internal diameter must be greater than the water pump inlet diameter. The external piping must connect to the engine through a flexible coupling to permit engine movement (vibration) and pipe thermal expansion.

Vertical Location

Vertical location of the radiator can be accommodated with the normal engine cooling system, up to the maximum Friction Head external to the engine and the maximum Static Head of the coolant above the engine. If the radiator must be located higher than allowable by either the Friction or Static Heads, then the radiator and engine coolant systems must be separated. A Hot Well Tank system will provide a common reservoir for both the radiator and engine. As the vertical height increases the piping quality must be better as the coolant pressure also increases.

Exceeding Friction/Static Head Pressures

If an installation is necessary that exceeds the specified Friction or Static Head pressures, it will be necessary to replace the engine water pump due to loss in water flow rate. The replacement pump must be sized to meet the engine water flow rate and pressures. In addition, revised thermostat or bypass connections will also be required with the replacement engine water pump.

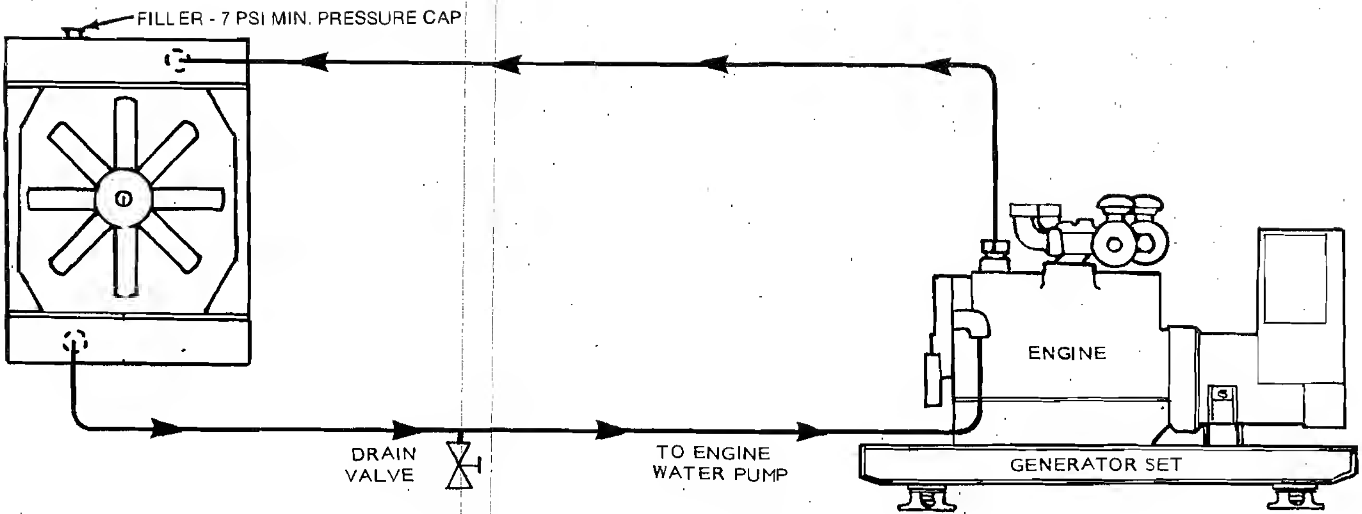


FIGURE 6. SHORT REMOTE RADIATOR INSTALLATION

Short Remote Radiator Installation

Figure 6 shows a schematic of an installation. The engine water pump provides adequate coolant circulation through the entire cooling system with proper plumbing.

Long Remote Radiator Installation

Figure 7 shows a schematic of the installation. A surge tank and auxiliary water pump (in conjunction with engine water pump) in the system provide adequate coolant circulation. See *"General Information"*.

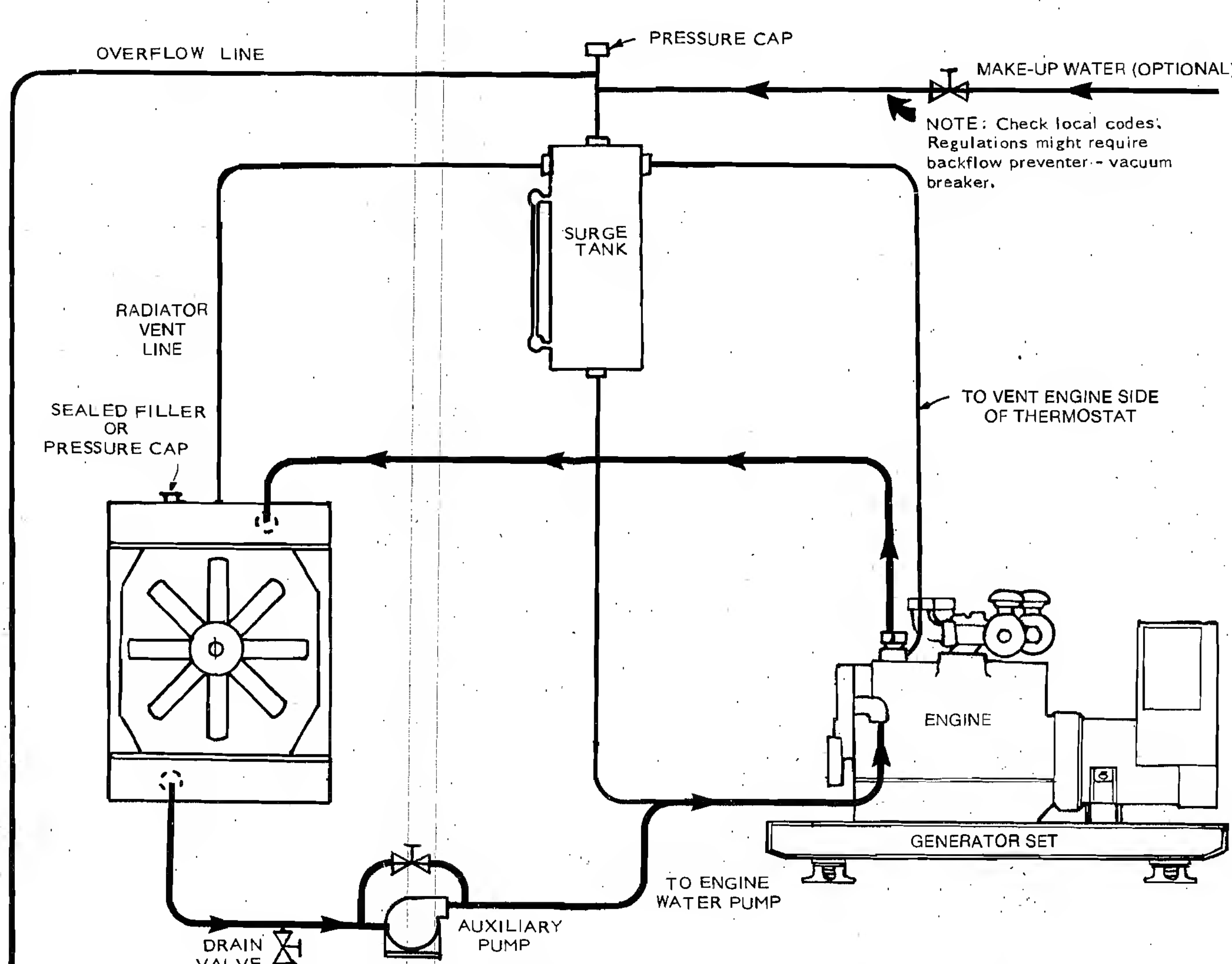


FIGURE 7. LONG REMOTE RADIATOR INSTALLATION WITH SURGE TANK

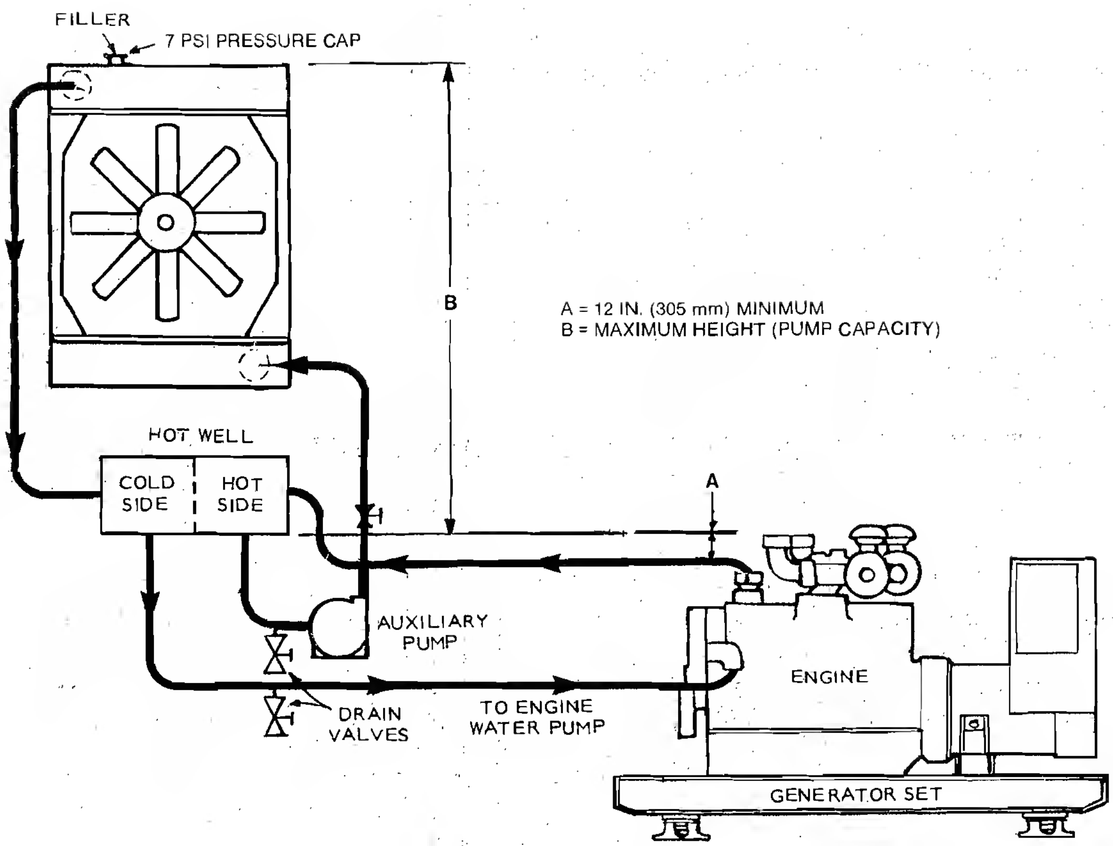


FIGURE 8. HIGH REMOTE RADIATOR INSTALLATION

High Remote Radiator Installation

If the static head exceeds the engine's limits a hot-well tank and auxiliary pump between the engine and the radiator are required. See Figure 8. The tank is a storage tank which reduces the water head pressure on the engine to acceptable limits. It is a two-section tank with a partial baffle to separate the hot side (engine outlet) from the cold side (engine inlet).

The engine pump circulates water between the engine and hot-well tank, and the auxiliary pump circulates water between the hot-well tank and remote radiator. The auxiliary pump must maintain the same water flow as the engine water pump. If not, a larger radiator is required.

Size the hot-well tank to contain the full-water capacity of the coolant in the engine, coolant jacket, radiator and piping. See Figure 9. The tank must have adequate volume so the inlets and outlets are submerged. In addition, the tank must also have adequate volume for an expansion air space. Inlets to the tank must be higher than the outlets with both being lower than the lowest possible operating water level. The radiator drains into the cold side of the tank after the GenSets shuts down. The tank baffle between the cold and hot sides must have an opening large enough to allow free water passage up to the rate of the GenSet or auxiliary pump, whichever is larger.

Maximum water level in the hot-well tank must never exceed the engine Static Head Pressure limit. The bottom of the tank must be a minimum of 12 inches (305 m) over the engine water outlet. Vertical height between the bottom of the hot-well tank to the top of the radiator is limited by auxiliary pump capability. Supports for the hot-well tank must withstand the weight of the water plus 60 percent of the cooling system capacity (when the GenSet is not running).

Mount the auxiliary pump at the tank hot side outlet below the running water level to prevent air from entering the pump during operation. If the proper pump and water line sizes are used, adequate water flow is maintained. For information on the pumps, see "General Information".

HEAT EXCHANGER COOLING DESIGN

Heat exchanger cooling eliminates the necessity of both a radiator and the associated cooling fan. City or raw water is used for cooling the engine coolant. Heat is radiated from the engine coolant to the heat exchanger. The heat exchanger radiates heat to the city or raw water.

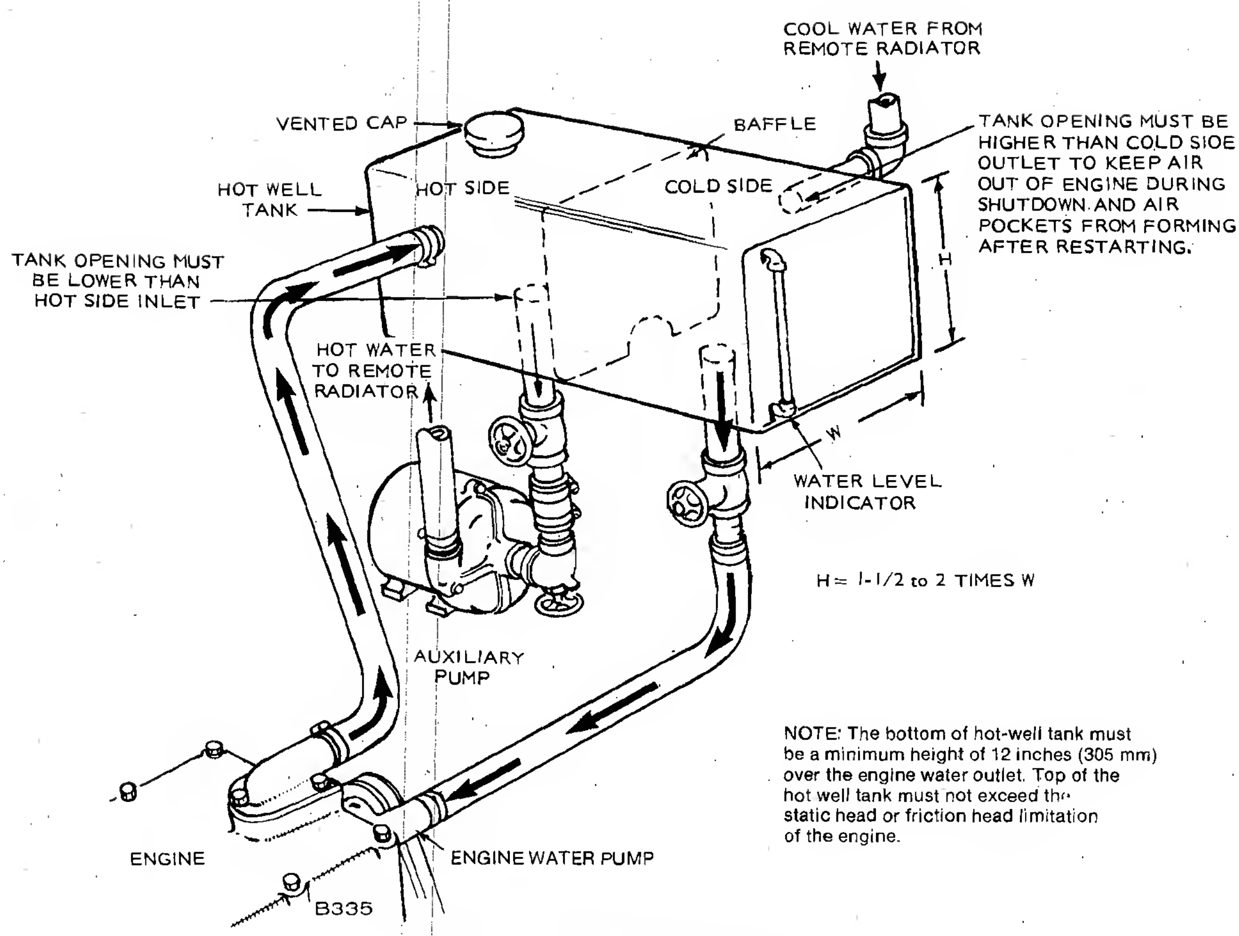


FIGURE 9. TYPICAL HOT WELL TANK

Heat Exchanger Installation

The heat exchanger consists of tubing within a surrounding "shell." Engine water in the shell side of the heat exchanger does not mix with city or raw water within the tubes (Figure 10). Raw water passing through the tubes absorbs engine heat from the separated engine coolant in the heat exchanger.

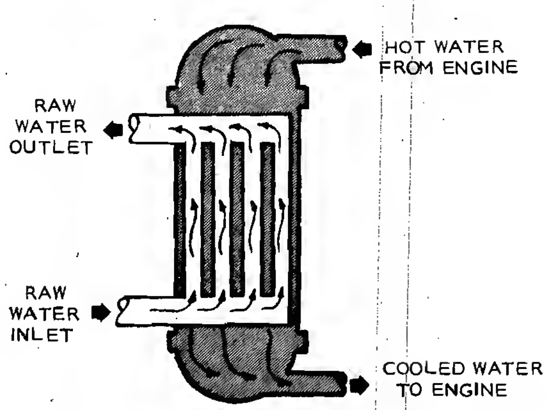


FIGURE 10. TYPICAL HEAD EXCHANGER

⚠CAUTION ***While you can protect the engine coolant from freezing with antifreeze solution, cooling raw water cannot be protected. If freezing temperatures are encountered, the heat exchanger's raw water system must be drained.***

Because the engine coolant is not mixed with the city or raw cooling water, the engine coolant can include antifreeze and anti-corrosion solutions for engine protection.

Flow rate of cooling raw water is controlled either by a manual or automatic valve. A manual valve must be adjusted for proper engine cooling while running under full load. If an automatic valve is used, the engine coolant outlet temperature must be used as an adjustment reference. A solenoid valve is included in the incoming raw water line and opens during GenSet operation. Figure 11 shows a heat exchanger system.

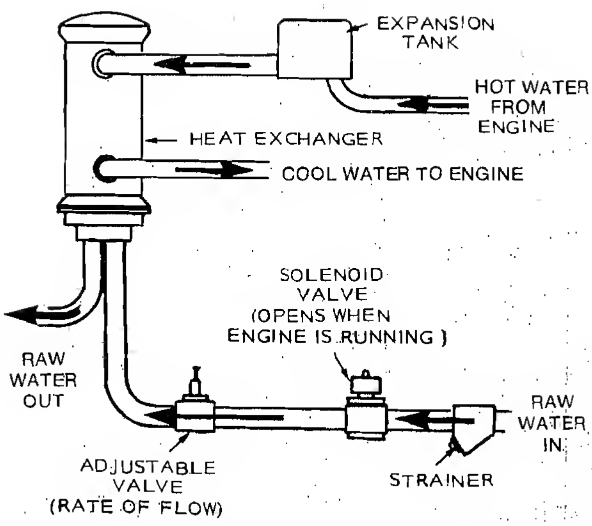


FIGURE 11. HEAT EXCHANGER SYSTEM

COOLANT HEATERS

Engine coolant heaters with thermostats, available from Onan, are important for any unattended, standby application. They increase:

1. Starting reliability,
2. Engine life.
3. Unit ability for load acceptance.

Due to the starting difficulty of diesel GenSets in cold temperatures, Onan recommends coolant heaters whenever the ambient temperature surrounding the set is 50°F (10°C) or lower. Thermostats are used to control operation of the heaters by sensing coolant or engine block temperature. Commercial power is used to operate the heater whenever the GenSet is idle.

Fuel System

For gaseous fuel systems such as natural, manufactured, or LP gas, see technical bulletin T-015, *"USE OF GASEOUS FUEL WITH ONAN ELECTRIC GENSETS"* for installation information.

⚠WARNING ***Fuel leaks create fire and explosion hazards which might result in severe personal injury or death. Carefully design and install the fuel system observing applicable codes.***

STORAGE TANKS

Tank Size

If the GenSet must run unmonitored for long periods of time, the fuel tank should be large enough to supply the engine for the expected time plus an extra safety factor time. Generally, fuel tanks should have the capacity to sustain full load operation of the GenSet for 36 hours without refueling.

Determine tank size by referring to the specification which gives fuel consumption for GenSet operation at 1/4, 1/2, 3/4 and full load. Fuel lifting capabilities are also stated. Onan can supply underground or above ground fuel tanks with 55- to 560-gallon (208 to 2120-litre) capacities. These tanks can accommodate a fill pipe, vent pipe, drop tube and two return lines.

Tank Location

The fuel tank can be installed above or below the ground but locate it near as possible to the GenSet in accordance with code restrictions. Because the fuel pump influences fuel tank location check (refer to specification) fuel pump lift. If the sum of fuel pressure drop and vertical lift exceeds the lift capabilities of the standard fuel pump use an auxiliary fuel pump and day tank.

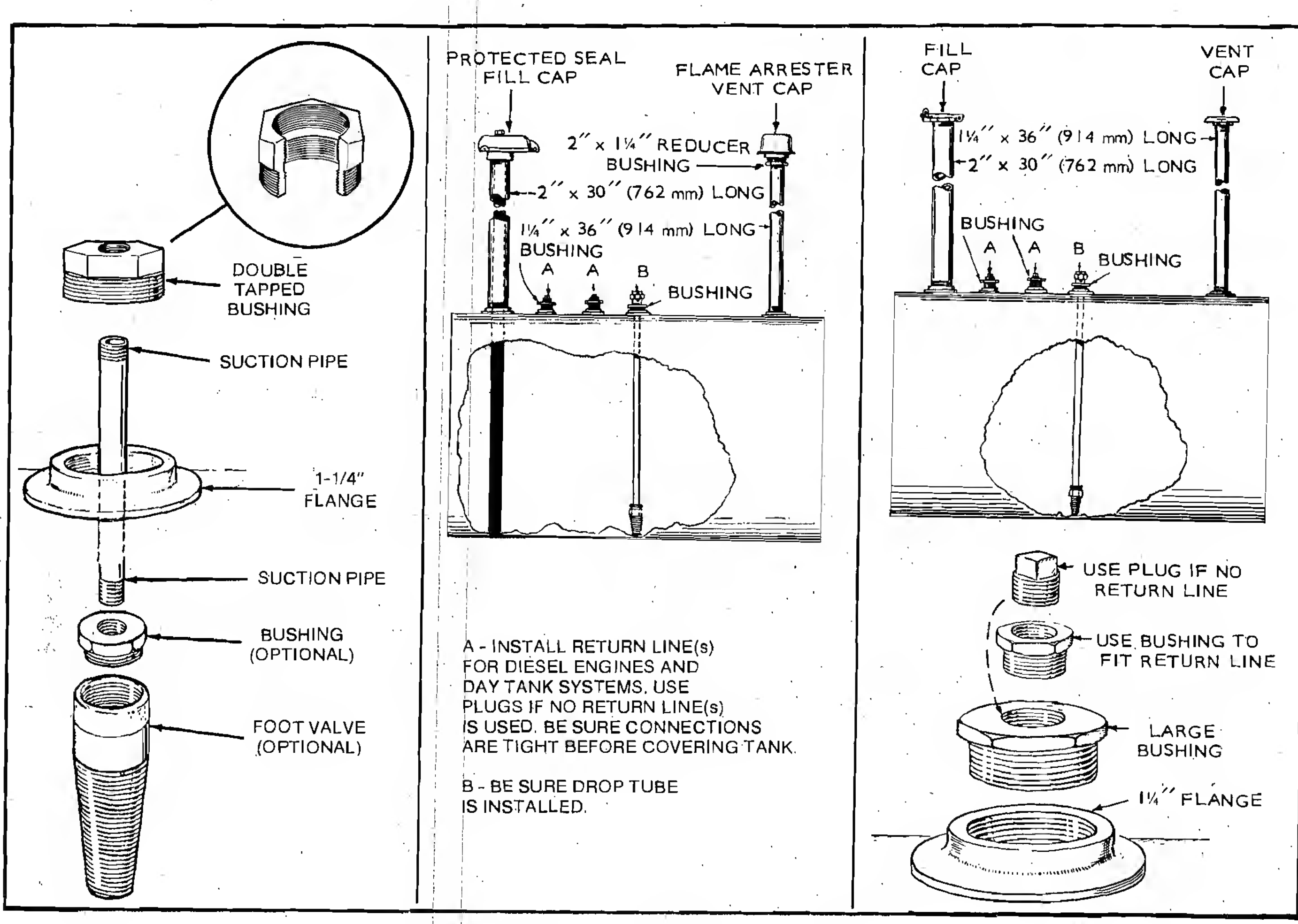


FIGURE 12. FUEL TANK FITTINGS

Day Tank

⚠WARNING ***Because of fire hazard which could result in severe personal injury or death, never install a fuel tank or fuel line near exhaust pipes.***

Day tanks are fuel transfer tanks used when the standard engine fuel pump hasn't the necessary lift to draw fuel from the supply tank (auxiliary pump is also required). For overhead fuel tanks, day tanks are used to remove fuel head pressures which otherwise would be placed on the engine fuel system components. See *"Diesel Day Tanks"* or *"Gasoline Day Tanks,"* whichever applies.

National Fire Prevention Bulletin No. 37 specifies that gravity feed of fuel is permitted only from integral tanks of 25 gallons (94.6 litres) or less. If the fuel tank is located higher than the GenSet and gravity feeds directly to the unit fuel pump, use an anti-siphon system for proper operation and safety with gasoline systems (See *"Gasoline Anti-Siphon System"*).

Primer Tank

A gasoline primer tank replenishes fuel evaporated from the carburetor of gasoline GenSets which require quick, dependable starts. See *"Gasoline Primer Tanks"* for more information.

Tank Fill and Vent Pipe

Figure 12 shows typical fuel tank fittings for the fill and vent pipes. If the fuel tank is underground, height of the pipes may vary. Make sure the fittings are air and moisture tight. Use a removable wire screen in the fill pipe neck, about 1/16-inch (1.6 mm) mesh, to trap contaminants whenever the tank is filled. The vent pipe must be high enough to meet fume abatement requirements.

Levelometer

The levelometer, available from Onan, is an easy-to-read fuel level indicating gauge. It functions with underground fuel tank installations up to 12 feet (3.7 m) deep. The gauge senses the fuel level hydrostatically, by pressure changes. See Figure 13.

Low Level Alarm Switch

The low level alarm switch S.P.D.T. (single pole double throw), available from Onan, accurately senses the fuel level hydrostatically, by pressure changes. See Figure 14. An alarm circuit (customer supplied) can be activated by the normally open or normally closed contacts of the switch.

For depths up to 10 feet (3 m) the riser extension pipe must be installed so the bottom inlet is 1 inch (25.4 mm) below the desired minimum fuel tank level. For each additional 10 feet (3 m) of depth the riser extension pipe should extend an additional 1 inch (25.4 mm) below the desired minimum fuel tank level. As an example, for a tank depth of 15 feet (4.6 m), switch actuation should occur when the fuel level drops within 1.5 inches (38 mm) of the riser extension pipe's bottom inlet.

All the switch and riser connections must be airtight to ensure proper operation. After the pipe connections are made from the tank, install the wiring and conduit between the switch and the alarm circuit.

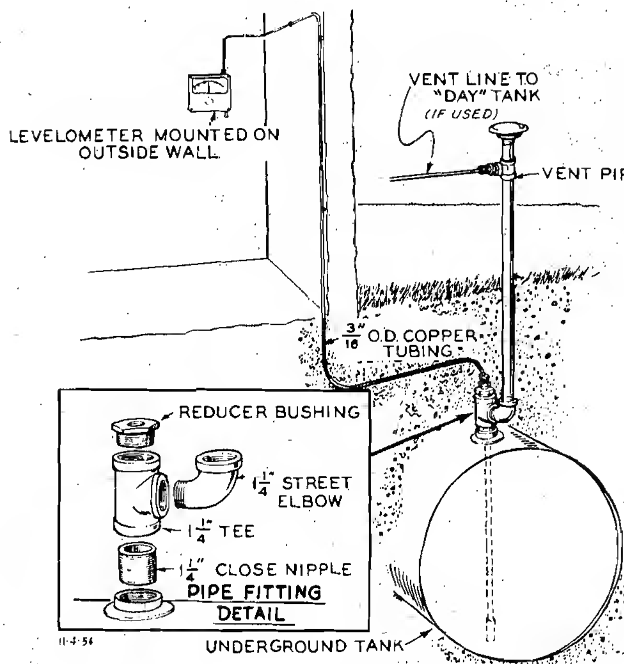


FIGURE 13. LEVELOMETER INSTALLATION

GENERAL FUEL PLUMBING

When buried fuel lines are used, use compatible metal fuel lines to avoid electrolysis. Onan has available copper fuel lines Table 3 with brass fittings used for underground fuel tanks.

⚠CAUTION ***Never use galvanized fuel lines, fittings or fuel tanks with diesel fuel systems. Condensation in the tank and lines combines with the sulfur in diesel fuel to produce sulfuric acid. The zinc coating on galvanized lines or tanks reacts with the acid and flakes off to contaminate the fuel.***

Use a flexible section of tubing (code approved) between the engine and fuel supply line to withstand GenSet vibration (note diesel GenSets also require a separate fuel return line). All fuel line and tank fittings must be properly located and airtight to keep air from getting into the fuel lines.

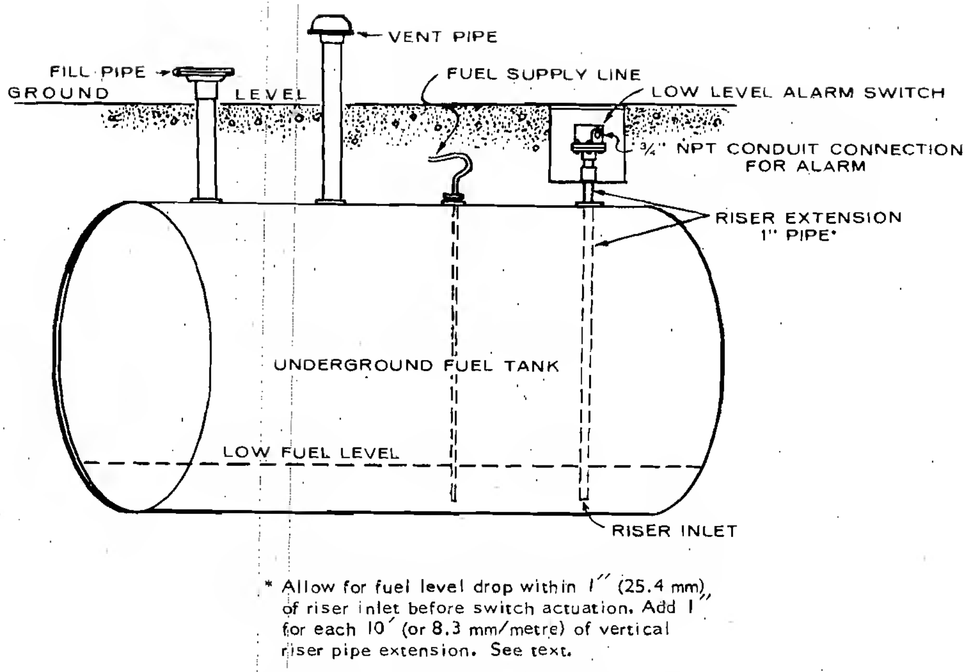


FIGURE 14. LOW LEVEL ALARM SWITCH INSTALLATION

Lifting capabilities are reduced by elbows, bends, and long lateral distances in the fuel line. Note during the descriptions of the various fuel systems using auxiliary fuel transfer pumps, the vertical lift is limited by the pump capability of the Onan transfer pump. With a larger capacity fuel pump, the vertical distance must not exceed 40 feet (12.4 m) lift. Fuel lifted long heights causes a pressure drop to the point where eventually the fuel boils, produces a vapor, and causes vapor lock.

Carefully clean all fuel system components before putting the GenSet in operation.

An electric solenoid shutoff valve in the supply line is always desirable and required for indoor automatic or remote starting installations. Connect the solenoid wires to the battery ignition circuit to open the valve during GenSet operation.

DIESEL DAY TANKS

Day tanks are fuel transfer tanks which are used when the standard engine fuel pump hasn't the capacity to draw the fuel from the supply tank; or, the supply tank is overhead and presents problems of high fuel head pressure for the fuel return. *Refer to Chart of Figure 15 for Maximum Allowable Static Head Pressure.*

Onan has day tanks with float switches available from 8 to 60 gallons (30.3 to 227 litres) in capacity. Day tanks with a float valve are also available (usually used with overhead fuel supply tanks).

Supply Tank Lower than Engine

With this installation (Figure 15), the day tank is installed near the GenSet and within the engine fuel pump lift capability, but below the fuel injection system (lift capabilities based on *no* horizontal run). An auxiliary fuel pump is installed close as possible to the supply tank and pumps fuel from the supply tank to the day tank. A float switch in the day tank controls operation of the auxiliary fuel pump.

The supply tank top must be below the day tank top to prevent siphoning from the fuel supply tank to the day tank.

On the Detroit Diesel engine only, a return line must be provided from the engine injection system return connection to the day tank (near the top) and extend down below the minimum fuel level of the day tank. Otherwise, drain-back from the engine fuel pump and filters may occur.

A day tank overflow (a size larger than supply line) must be provided to the supply tank in case the float switch fails to shut off the fuel transfer pump (Figure 15).

FUEL RETURN LINE - MAXIMUM STATIC HEAD PRESSURE

Engine	Maximum Head
Allis Chalmers with Roosa pumps	5 psi (3.45 kPa)
Allis Chalmers with Bosch pumps	5 psi (3.45 kPa)
John Deere	5 psi (3.45 kPa)
Ford	Not above injector nozzle
Cummins	4 psi (27.6 kPa)
Waukesha	Not above injector nozzle
Onan 4 cyl.	9 Feet (2.74 m)
Onan 2 cyl.	9 Feet (2.74 m)
Onan 1 cyl.	Not above injector nozzle
Perkins	12 Feet (3.7 m)
Onan DV Series	32 Feet (10 m)

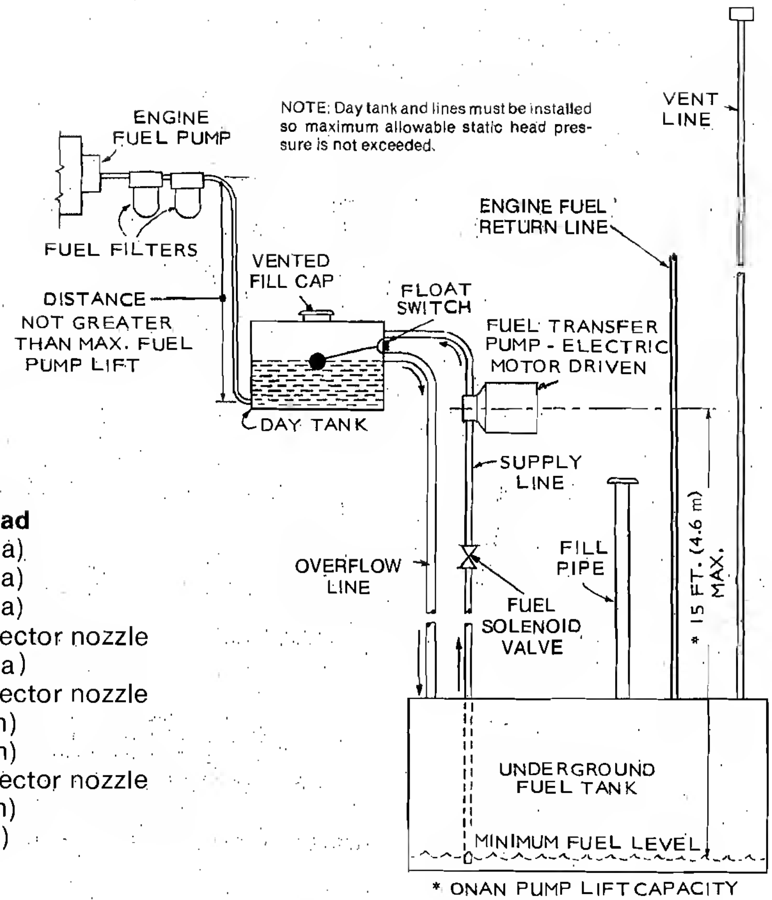


FIGURE 15. TYPICAL DIESEL FUEL SYSTEM WITH SUPPLY TANK BELOW GENSET

Supply Tank Above Engine

Due to the danger of hydraulic lock (fuel trapped on top of pistons) which causes serious engine damage, do not use a gravity feed fuel system directly to the engine fuel pump. The problem of such a system is the head on the engine fuel return line due to the overhead tank.

Figure 16 shows a typical installation when a day tank is used with overhead fuel supply tanks for diesel engines. The day tank is installed near the GenSet and within the engine fuel pump life capability, but below the fuel injection system. Use fuel line at least as large as the fuel pump inlet. On Detroit Diesel, the engine fuel return line must enter the day tank and extend down below the minimum fuel level of the day tank. Otherwise, drain back of fuel from the engine fuel pump and filters may occur when the GenSet is not operating.

On all other engines (i.e. Onan, Cummins, John Deere, etc.) the fuel return must enter the top of the day tank as far away as possible from the day tank outlet.

Observe in Figure 16 that a shutoff solenoid is included in the fuel line between the fuel supply tank and the day tank. It stops fuel flow when the run circuit is de-energized.

GASOLINE DAY TANKS

Installations with gasoline day tank systems have many of the same requirements as the diesel day tank systems discussed earlier. The day tank must be located below the carburetor, but within lift capability of the engine fuel pump. Day tanks for gasoline fuel systems do not use a fuel return line from the engine. Follow building codes for gasoline system details.

⚠WARNING ***Do not use a vented fill cap on the day tank with a gasoline fuel system as escaping gasoline fumes could be ignited resulting in severe personal injury or death.***

GASOLINE PRIMER TANKS

Gasoline evaporates from the carburetor bowl during long shutdown periods. Onan offers gasoline primer tanks, on some models of gasoline fueled GenSets, which gravity feed fuel to the carburetor. This ensures an immediate supply of fuel upon engine cranking. See Figure 17. A solenoid operated shutoff valve, open when the GenSet is running, is used between the primer tank and the carburetor. When the GenSet shuts down, the solenoid operated valve closes to prevent fuel from draining into the carburetor.

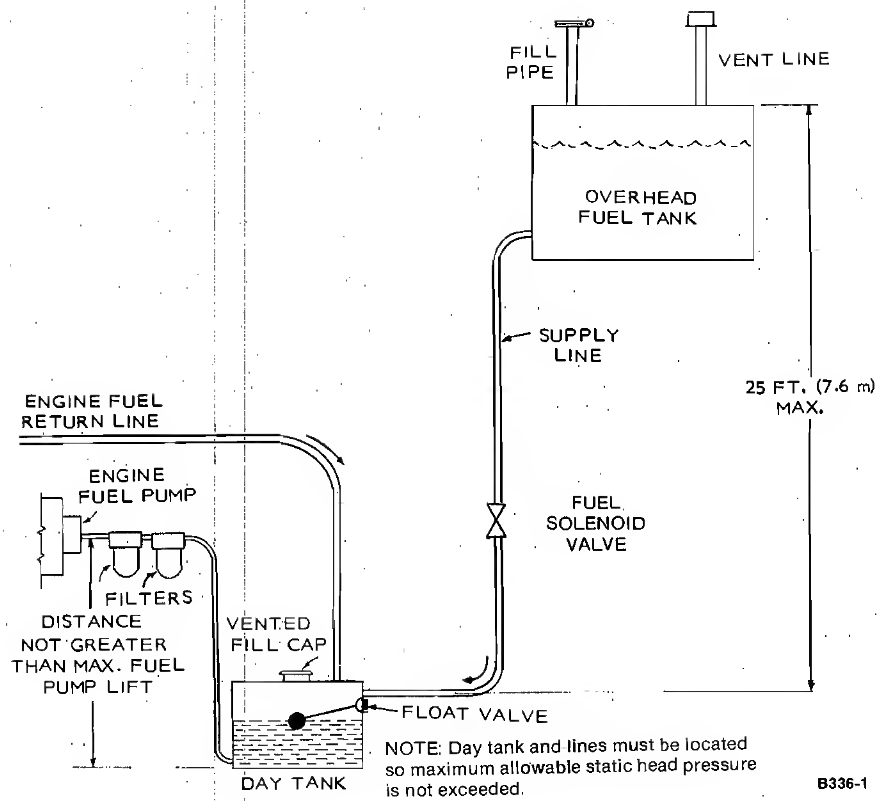


FIGURE 16. TYPICAL DIESEL FUEL SYSTEM WITH OVERHEAD FUEL TANK

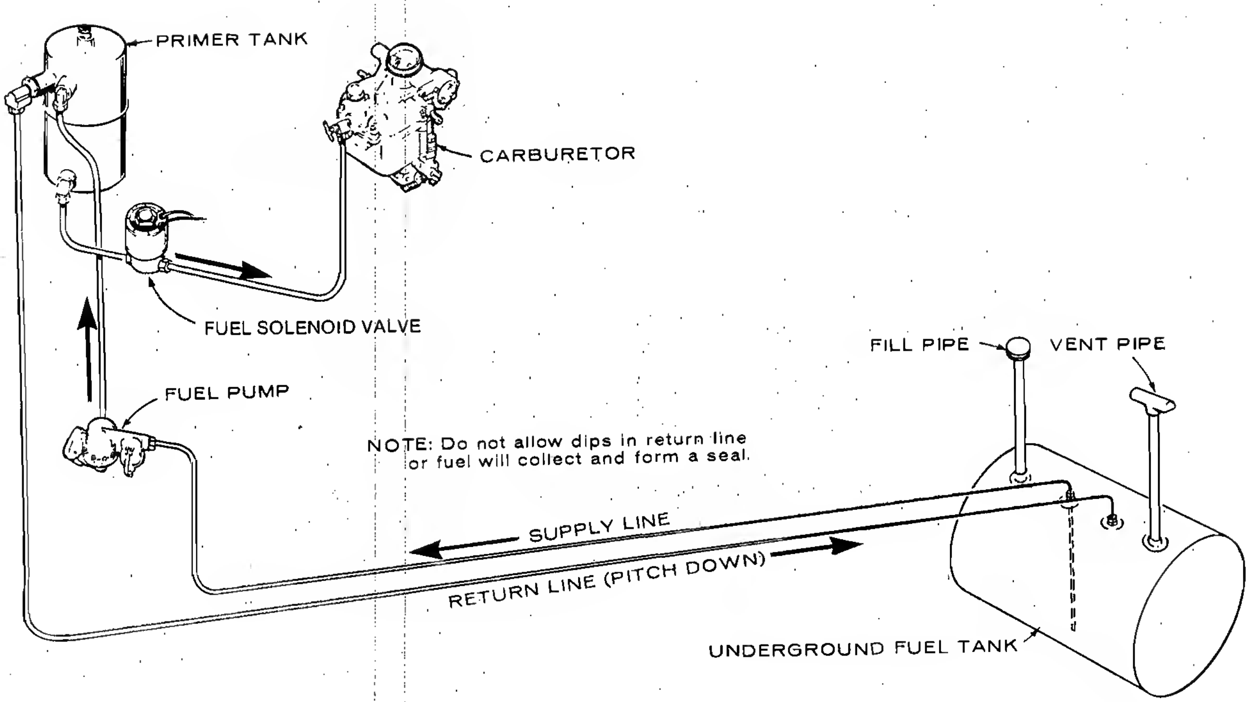


FIGURE 17. GASOLINE PRIMER TANK SYSTEM

The primer tank is pressurized by using a restrictive bushing in the return line. The return line to the supply tank, serving as a vent, will not gravity feed if the line includes any dips which trap fuel and block free air movement through the line.

GASOLINE ANTI-SIPHON SYSTEM

An anti-siphon system is often used when the fuel tank is located above the GenSet. It prevents siphoning of fuel directly to the engine fuel pump through use of special design plumbing. See Figure 18.

Fuel from the supply tank fills a void created in a vacuum pipe by the engine fuel pump. The vacuum pipe is about (4) four times greater in diameter than the line leading from the fuel tank to the vacuum pipe. For example, if the fuel line between the fuel tank and vacuum pipe is 5/16 inch, then the vacuum pipe is 1-1/4 inches.

Vacuum Pipe Assembly

The vacuum pipe assembly creates a head of priming fuel and consists of a vacuum pipe, manual shutoff valve, and priming plug. The vacuum pipe must be at least 4-times the diameter of the fuel line and long enough to extend above the fuel level in the fuel storage tank and below the engine fuel pump. The manual shutoff valve must be located between the vacuum pipe and the engine fuel pump. The priming plug must be located near the bottom end of the vacuum pipe.

To prevent exceeding the vacuum capabilities of the fuel pump but generate enough vacuum to lift fuel from the storage tank, the vacuum generated by "A" (head of priming fuel) must be equal or greater than the lift needed to overcome "B" (head of fuel).

The fuel storage tank head of fuel line must be high enough to allow an adequate level of head priming fuel.

The distance from the bottom of the fuel line to the priming plug "A" (head of priming fuel) must not exceed the height of the fuel line "B" (head of fuel) extending above the fuel storage tank.

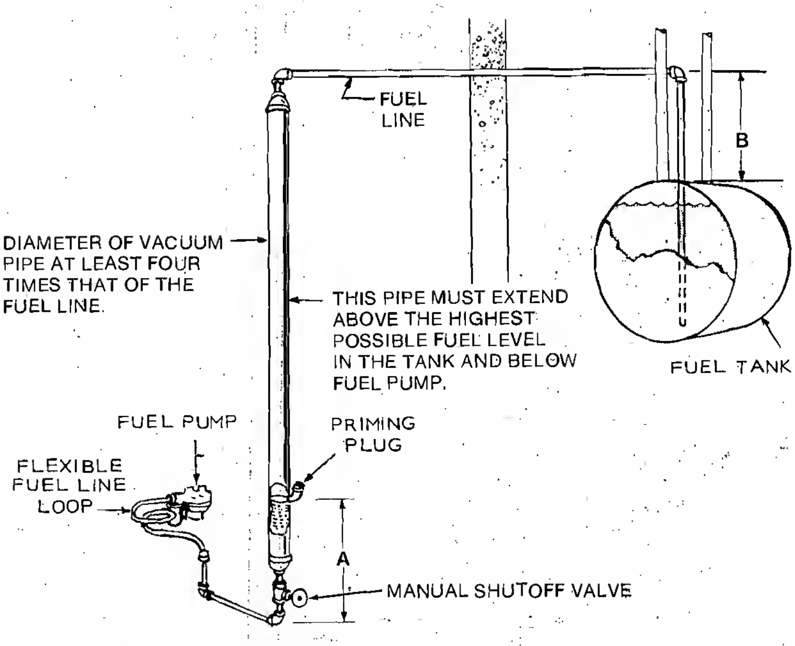


FIGURE 18. GASOLINE ANTI-SIPHON FUEL SYSTEM

Exhaust System

The purpose of the exhaust system is to direct engine exhaust from the engine and allow the exhaust to discharge into the atmosphere. A muffler should be connected into the exhaust system, either inside or outside the GenSet enclosure. For maximum efficiency, operation economy, and prevention of engine damage, design the exhaust system so it does not create excessive back pressure on the engine. Choice of proper pipe size, connections and muffler, if properly installed, will ensure satisfactory operation.

WARNING ***Plan the exhaust system carefully. Exhaust gases are deadly! Pipe exhaust gases outside away from windows, doors or other inlets to building. Exhaust pipes must not terminate near inlet vents or combustible materials. If exhaust gases are piped into a chimney, the point of entry must be above flues and vents. Check exhaust systems visually and audibly at frequent intervals for leaks and repair as necessary.***

When exhaust gases must pass through a floor, ceiling, attic or concealed space, the exhaust pipes should be routed to or pass inside of a metal, masonry or other approved chimney. If other fuel burning appliances are vented into the same chimney, the engine exhaust pipe must extend up into the chimney beyond any other flue connection.

EXHAUST MANIFOLD

GenSet engine exhaust manifolds provide the channeling for exhaust gases from each cylinder to an exhaust outlet. The manifold affords a minimum of back pressure and turbulence to the engine cylinders and valves. GenSets are equipped with various types of manifold.

Two types of manifolds used are the standard dry aircooled manifold and the water jacket watercooled manifold. The water jacket watercooled manifold applies water directly on the manifold while the aircooled and watercooled watershielded manifold circulates water in a sealed water jacket with an air space between the water jacket and the manifold.

EXHAUST PIPING

Every possible precaution must be taken to prevent back pressure on the engine cylinders and valves. Excessive back pressure can be caused by the following:

Piping too long
Piping diameter too small
Obstructions in exhaust system
Too many sharp bends in piping
Too much carbon buildup in exhaust system

Exhaust pipes must comply with applicable Local, State or National codes. Where such codes are not available, for safety comply with the following:

Exhaust pipes should be wrought iron or steel and strong enough to withstand the service.

Exhaust pipes must be free standing, not supported by engine or muffler.

Exhaust pipes must use vibration proof flexible connector.

Exhaust pipes must have a clearance of at least 9 inches (229 mm) from combustible materials and terminate outside of building.

Exhaust pipes must be guarded to prevent burning of personnel.

Exhaust pipes must avoid fire detection devices and automatic sprinkler alarm heads.

Exhaust pipes must be vented to the atmosphere away from building doors, windows and ventilation intake vents.

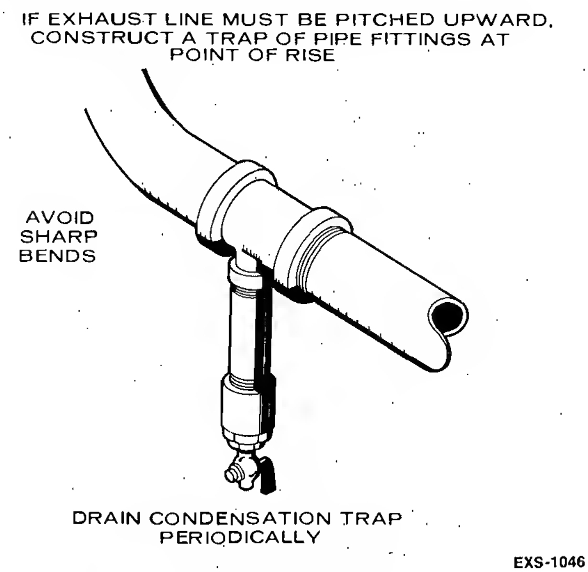


FIGURE 19. CONDENSATION TRAP

CAUTION ***Total back pressure of all system components must not exceed maximum back pressure limits. Otherwise, engine damage can result.***

Pitch exhaust pipes downward away from the GenSet in a horizontal run or install a condensation trap with a means of drain where a rise in the exhaust system begins. Figure 19 shows a typical condensation trap. Be sure a flexible pipe section is included at the engine and the system is properly supported.

Flexible Pipe Section

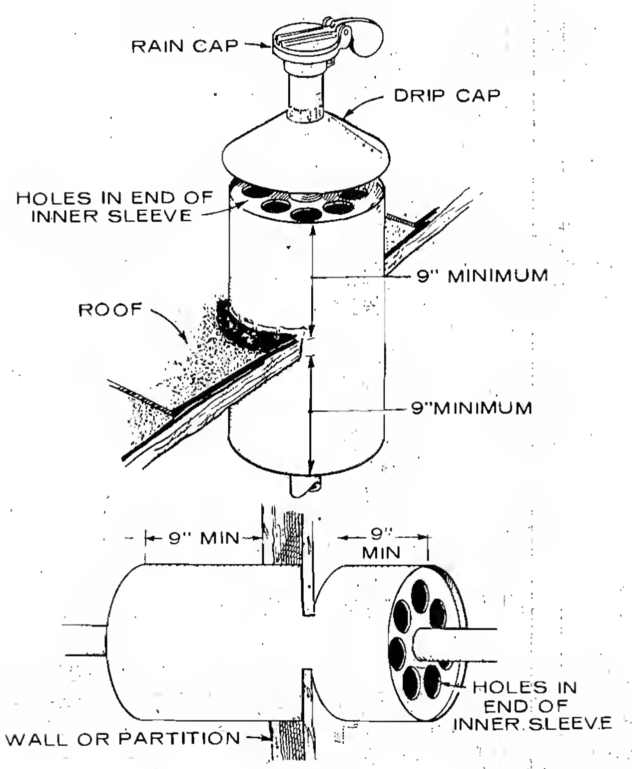
A piece of flexible, bellows type exhaust pipe must be used between the engine exhaust connection and the exhaust piping system to permit GenSet movement and thermal expansion of piping without placing stress on the exhaust system. When selecting flexible pipe and length, consider:

1. Vibration isolators used—allow for 1 inch (25 mm) movement of engine exhaust outlet in all directions.
2. Expansion of pipe—depending on exhaust pipe support, note which direction expansion occurs.

Thimble and Rain Caps

An approved thimble must be used (Figure 20) where exhaust pipes pass through walls, partitions or roofs. Build the thimble according to codes (see National Fire Protection Association bulletin, Volume 4, section 211 on "Standards for Chimneys, Fireplaces and Vents"). Install a drip cap on the thimble when installed vertically as shown in Figure 20.

Onan has rain caps available for the discharge end of vertical exhaust pipes. The rain cap clamps onto the end of the pipe and opens due to exhaust discharge force from the GenSet. When the GenSet is stopped, the rain cap automatically closes, protecting the exhaust system from the environment.



EXS-1036

FIGURE 20. EXHAUST PIPE THIMBLE, THROUGH ROOF, WALL OR PARTITION

Exhaust System Support

The exhaust system components attached to the GenSet support reasonable piping loads.

Some GenSet models use turbochargers. Turbochargers operate at high speeds and employ closely fitted bearings and impeller. The turbo is built to pump large quantities of air. It is not capable of supporting the weight of long runs of pipe or mufflers.

With the typical pipe diameter and weight used in todays GenSet installations a support will probably be required within 6 or 7 feet (1.83 or 2.13 m) of a naturally aspirated manifold. This distance may have to be shortened due to high shock loads. A support will be required within 4 feet (1.22 m) of a turbocharger. An 18 inch (457.2 mm) length of flexible exhaust tubing properly mounted to the manifold will prevent an exhaust system from overstressing the GenSet.

Exhaust Back Pressure

The exhaust back pressure of the GenSet when measured at full load and governed engine speed must not exceed the value indicated on the Product Data Sheet.

The exhaust back pressure depends on the size of exhaust pipe, number and types of bends and fittings, together with the selection and location of the muffler. Pipe size for a typical installation presumes a minimum of short radius bends and reducers. Tight bends are usually the highest contributor of back pressure. Since restriction is inversely proportional to the fifth power of the pipe diameter, a small increase in pipe diameter will drastically reduce the pressure restriction due to the pipe.

An approximation of back pressure can be obtained using the following example:

For a GenSet with an exhaust gas flow of 2000 cfm (56.64 m³/min) a typical system may calculate as follows:

ITEM		BACK PRESSURE
Muffler (1)		= 0.750 in Hg (2.54 kPa)
12 ft. of 6 in. piping	= 12 x 0.0067	= 0.0804 in Hg (0.27 kPa)
18 in. 6 in. flex tubing	= 1.5 x 0.0067 x 2	= 0.0201 Hg (kPa)
Four 6 in. 90° elbows	$= \frac{16 \times 6 \times 4}{12} \times 0.0067$	= 0.2144 Hg (0.07 kPa)
9 ft. of 6 in. piping	= 9 x 0.0067	= 0.0603 Hg (0.20 kPa)
		1.1252 Hg (3.80 kPa)

(1) Muffler back pressure can be obtained from Onan or the manufacturer of the muffler.

Use Back Pressure Nomograph, Figure 21 to determine exhaust pipe and elbow contribution to back pressure levels. Calculated back pressure is an approximation of average pipe friction and must be verified by actual test measurement.

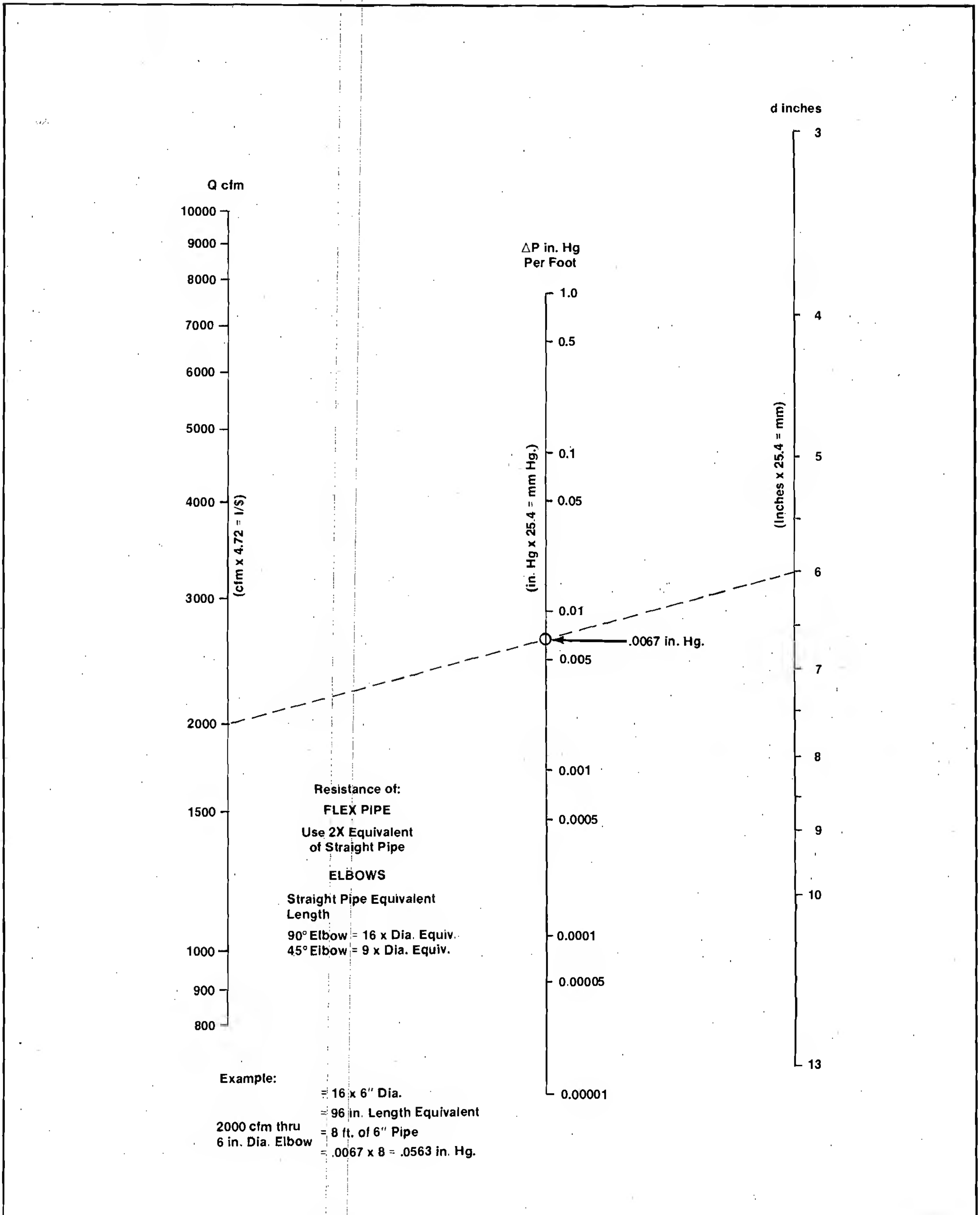


FIGURE 21. BACK PRESSURE NOMOGRAPH

Checking Exhaust System

Use a manometer scaled to read in excess of 40 in. H_2O. Connect the manometer to the exhaust system close to the exhaust manifold outlet in a straight line section of pipe.

Operate the GenSet at rated speed and load and record the manometer reading. Check the allowable exhaust back pressure on the GenSet Product Data Sheet.

⚠CAUTION ***Weight applied to the engine manifold or turbocharger can result in manifold or turbocharger damage.***

MUFFLERS

Select a muffler to reduce noise of the exhaust system to levels required at the installation site. Onan mufflers are listed in Accessory Specifications. Three muffler types are available.

1. Industrial Muffler—Suitable for industrial areas or remote installation where attentuation is not critical.
2. Residential Muffler—Suitable where some low background noise is always present.
3. Critical Muffler—Suitable for the areas of hospitals, residential dwellings, etc. where background noise is minimal.

Attenuation is sound reduction given in decibels. Typical attenuation curves for industrial, residential and critical mufflers are shown in Figure 22.

For determining approximate sound level reduction for different distances from the sound source, subtract six decibels every time the distance is doubled. As an example, a sound level of 92 decibels at 100 feet (30 m) will be approximately 80 decibels at 400 feet (120 m).

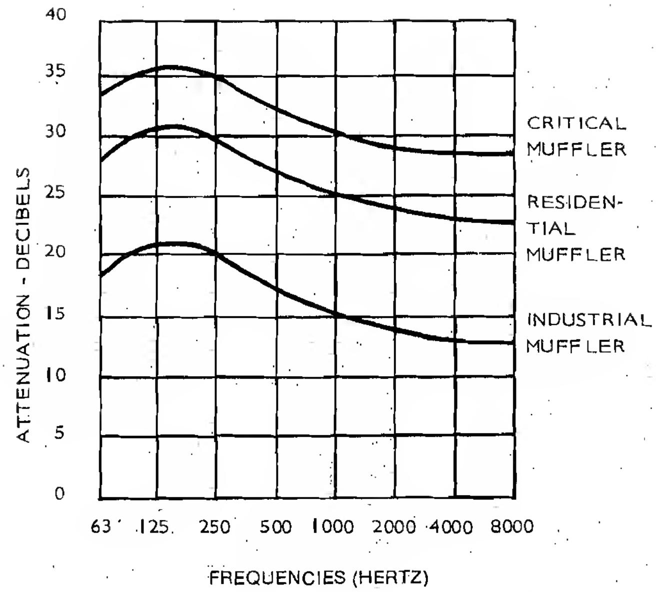


FIGURE 22. TYPICAL MUFFLER ATTENUATION CURVES

Location

Install the muffler as close as possible to the engine. Cool mufflers collect undesirable carbon residues and moisture.

Draining and servicing the muffler is more convenient if installed near the engine.

Installation

If the muffler is installed near the engine and is within reach of personnel standing on the installation floor level, protect it with a guard and insulation. If the muffler is installed outside the installation enclosure, it should have a guard or shield around it.

Electrical Systems

ELECTRICAL SYSTEMS

The electrical systems consist of AC power, DC control and DC starting. The AC power and DC control systems wiring must be enclosed in separate solid conduits.

⚠CAUTION ***Do Not install DC control wiring in the same conduit as the AC power. AC voltage induced currents can create operational problems with electronic solid-state devices.***

Most local regulations require that a licensed electrician perform wiring and wiring connections to a GenSet. A local inspector must approve the installation prior to equipment operation. All conduit, wire sizes, connections, etc. must conform to specifications, installation instructions, local codes and regulations.

AC ELECTRICAL POWER SYSTEM

⚠CAUTION ***Observe GenSet and load(s) phase wiring. GenSets typically rotate counterclockwise while utilities typically rotate clockwise, thus reversing phases. Reversed phases will prevent synchronizing GenSets and cause circuit breakers to trip.***

Install solid conduit with a flexible section at the GenSet control box. from the GenSet to the AC load (AC power cables to switchboard or transfer switch). The flexible section of conduit prevents GenSet vibrations from generating damaging stresses on the solid conduit or GenSet control box.

DC ELECTRICAL CONTROL SYSTEM

Install solid conduit with a flexible section at the GenSet control box, from the GenSet to the DC control (Start-Remote-Stop and Faults wiring to switchboard or transfer switch). The flexible section of conduit prevents GenSet vibrations from generating damaging stresses on the solid conduit or GenSet control box.

If the installation is a standby system, use a double-throw transfer switch (manual or automatic) which protects against the possibility of commercial and generator power connecting to the load at the same time. Instructions for connecting transfer switches are included with the transfer switch equipment.

DC ELECTRICAL STARTING SYSTEM

A battery-powered electric motor performs the starting of all Onan liquid-cooled GenSets. Cranking speed depends on battery capacity, oil viscosity and ambient temperature around the GenSet. Follow the battery recommendations in the Onan specification sheets and operator's manuals for the GenSets.

For low temperatures, use engine coolant heaters, lube oil heaters, etc. to ensure starting dependability (especially important with diesel sets).

Battery Location

Resistance in the starting circuit wiring has a significant effect on starting ability of the engine. Therefore, locate the batteries as close as possible to the GenSet (batteries must be accessible for servicing).

If the batteries are located relatively far from the starter motor, increase the battery cable size to avoid excessive voltage drop.

Most Onan sets have a "built-in" battery rack for the batteries. For the other models, mount the batteries on a wood or metal platform close to the GenSet.

Battery Charger

Most standby GenSets run too seldom to maintain full charge of the starting batteries. For such installations, a battery float charger is desirable because it can maintain battery potential after a start cycle of the GenSet. The battery charger is connected to the AC line source so it operates constantly during normal power.

A float charger is not designed to recharge batteries quickly.

Onan also has an SCR equalize battery charger with a charge timer which has a maximum charge rate up to 10 amperes for 12-volt systems and up to 6 amperes for 24-volt systems. For fast charging, the equalize charge timer can be manually set for any time period up to 12 hours (most battery manufacturers recommend 24 hours of equalize charging every month). Setting the timer raises the charger's output and maintains high charging voltage for the selected time. After this period, the timer automatically switches back to float voltage.

Nickel cadmium batteries do not require equalize battery charging.

Typical Installations

Following (Figures 23 and 24) are typical installations, one of a gasoline GenSet with radiator cooling and another of a diesel set with radiator cooling. For installation details on the individual GenSet, consult the Onan specification sheet and operator's and installation manuals.

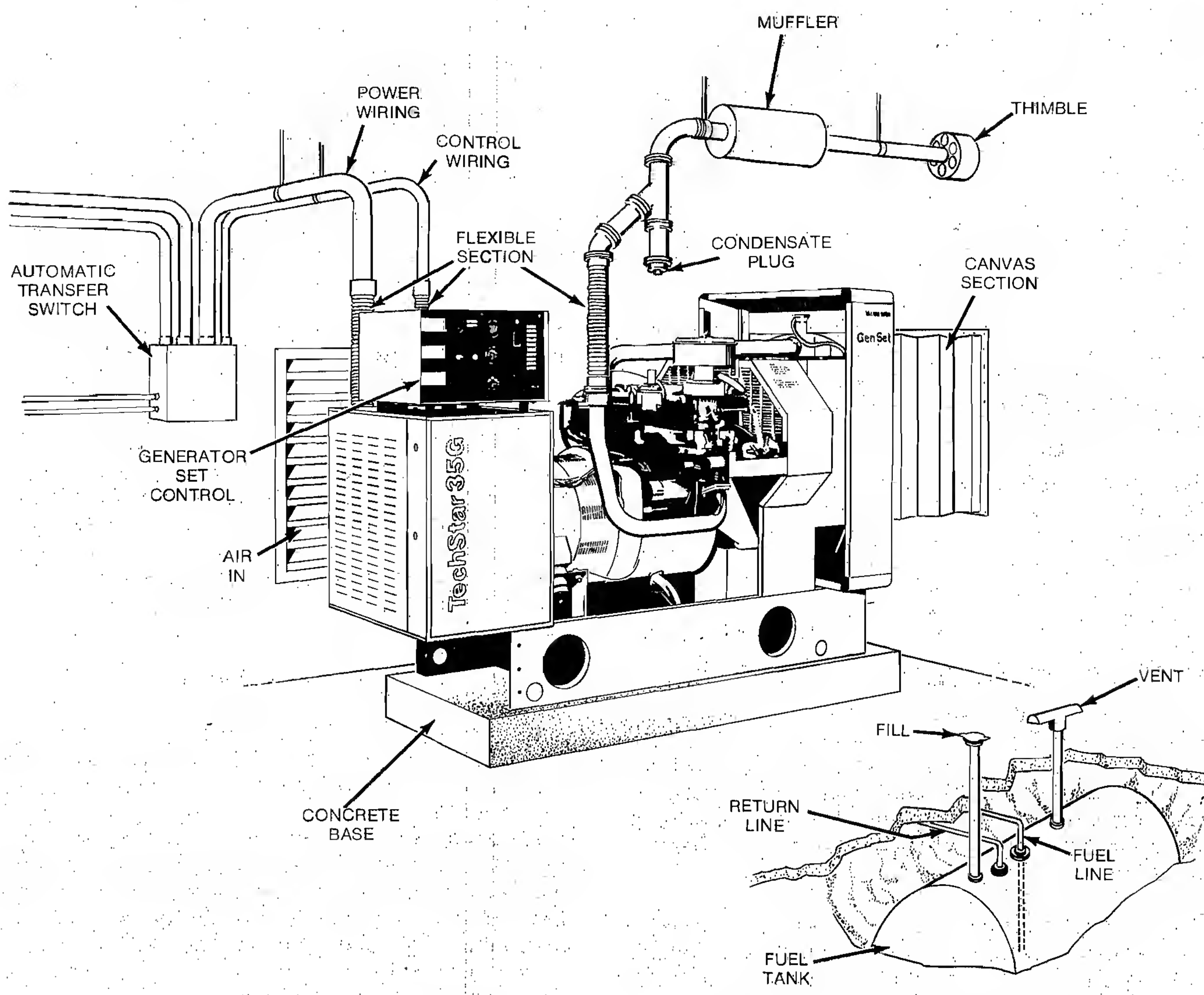


FIGURE 23. TYPICAL GASOLINE INSTALLATION, RADIATOR COOLING

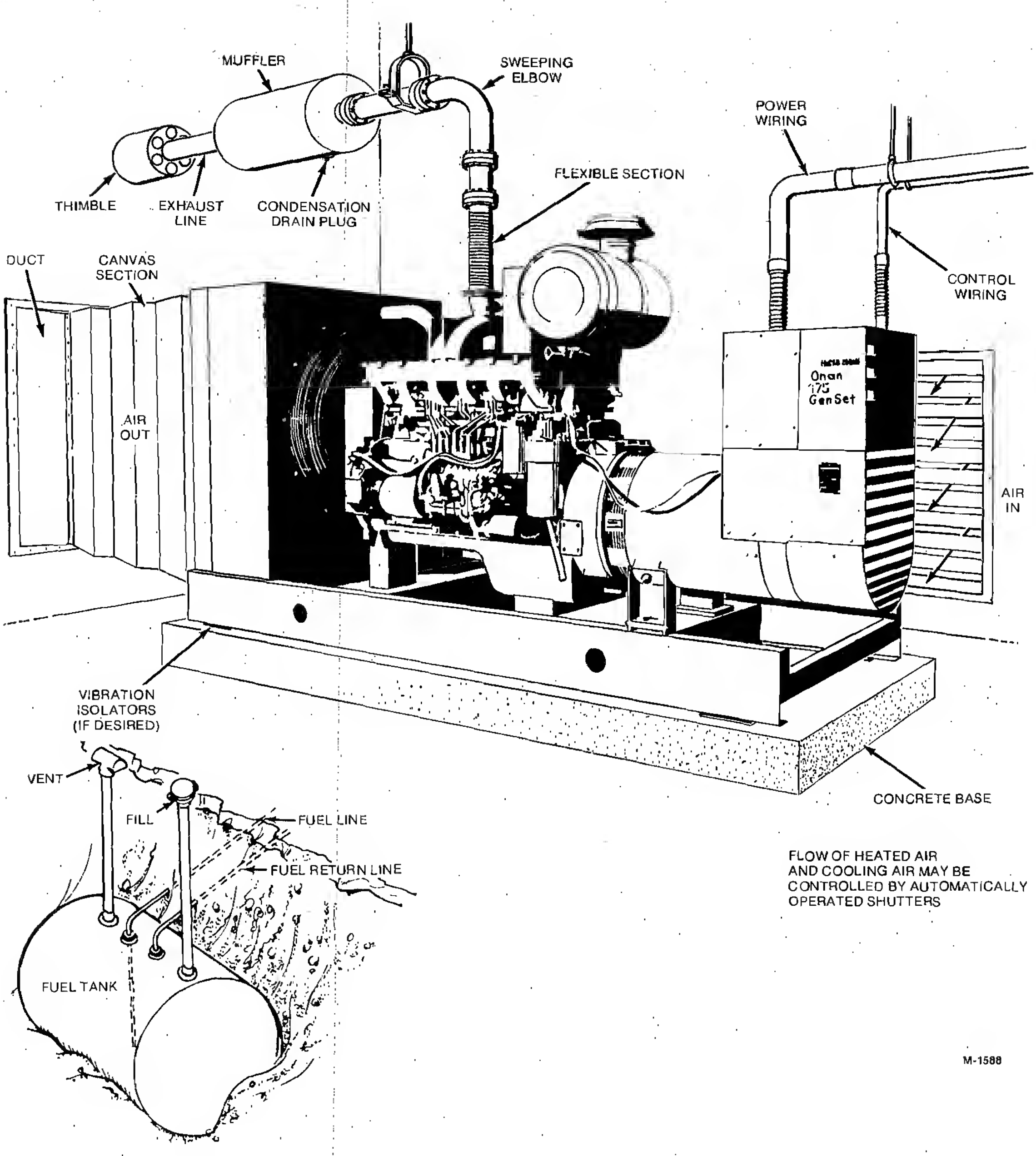


FIGURE 24. TYPICAL DIESEL INSTALLATION, RADIATOR COOLING

Index of Tables

TABLE TITLE **PAGE**

TABLE 1. HEAT LOSS FROM UNINSULATED EXHAUST PIPE AND MUFFLERS

PIPE SIZE	Uninsulated, Steel Pipe Heat Loss		Uninsulated, Critical Muffler Heat Loss	
Inch	BTU/Hr/Linear Foot	MJ/Hr/Linear Metre	BTU/Hr	MJ/Hr
1.5	2,800	0.9004	17,800	5.7238
2	3,400	1.1190	29,400	9.4540
2.5	4,180	1.3441	47,100	15.1454
3	5,040	1.6207	66,000	21.2232
3.5	5,750	1.8490	84,500	27.1721
4	6,450	2.0741	106,000	34.0858
5	7,930	2.5500	150,000	48.2346
6	9,350	3.0066	213,000	68.4931
8	12,000	3.9231	328,000	105.4730
10	14,950	4.8074	510,000	163.9980
12	17,600	5.6595	605,000	194.5460

TABLE 2. AUXILIARY WATER PUMPS

CAPACITY 40 FT (12.2 m) MAX. HEAD		MOTOR HP At 3600 RPM		PUMP SIZE Suction x Discharge x Impeller	MODEL NO. *Female N.P.T. **150E ASA Flat Faced Flange
Gal/Min.	Litre/Min.		kW		
0-41	0-155	.75	.56	1¼ x 1 x 4	*D520
42-55	159-208	1.0	.75	1¼ x 1 x 4	*D520
56-63	212-238	1.0	.75	1½ x 1 x 4	*D520
62-74	235-280	1.5	1.12	1½ x 1 x 4	*D520
74-96	280-363	1.5	1.12	2 x 1½ x 4	*D520
96-120	363-454	2.0	1.49	2 x 1½ x 4	*D520
120-165	454-624	3.0	2.24	2 x 1½ x 4	*D520
165-300	624-1136	5.0	3.73	2½ x 2½ x 4	*D520
300-350	1136-1325	7.5	5.59	3 x 2 x 5	*D820
350-450	1325-1703	7.5	5.59	4 x 3 x 5	*D1020
450-550	1703-2082	10.0	7.46	4 x 3 x 5	*D1020

Pumps have 3 phase, 230/460 volt, open drip-proof motors. Three phase, 200 volt or 208 volt, drip-proof motors are available with extended lead time upon request. Pumps have mechanical seals and 316 stainless steel internals and all are rated at 3600 RPM.

TABLE 3. COPPER FUEL LINES AVAILABLE FROM ONAN

Supply	Type of Line Use Return (No Tank)	Return (Tank)
5/16	5/16	5/16
3/8	3/8 - 5/16	1/2
5/8	1/2	5/8
1/2	3/8	1/2

GLOSSARY OF TERMS

DAY TANK - a type of fuel transfer tank normally used when the engine fuel pump does not have the capacity to draw fuel from the main fuel tank. Also used together with overhead fuel tanks to remove fuel head pressures.

DEAERATION - to remove air from cooling system, a function of vented radiators, Surge, and Hot Well tanks.

HEAT EXCHANGER - A shell encasing a number of tubes. Engine water flows through the shell while city water (raw water) flows through the tubes.

HIGH REMOTE RADIATOR - used on installations where either a short or long remote radiator are not practical. Vertical location of the radiator can be accommodated with the normal engine cooing system, up to the maximum Friction Head Pressure external to the engine and the maximum Static Head Pressure of the coolant above the engine.

HOTWELL TANK - is a single tank with a partial hot and cold water baffle separator. Normally used when engine remote radiator is located above engine.

HORIZONTAL CORE - an optional mounting position of a remote radiator.

HYDROSTATIC PRESSURE - the pressure exerted by a liquid, relative to the function of a Levelometer, used to measure the amount of fuel (gasoline or diesel) in an underground tank.

LEVELOMETER - a fuel gauge that functions using the hydrostatic principle of operation.

LONG REMOTE RADIATOR - used on installations where neither a short or high remote radiator are practical. Horizontal distance can be accommodated with the normal engine cooing system, up to the maximum external Friction Head Pressure.

PRIMER TANK - a gasoline tank that replenishes fuel evaporated from the GenSet carburetor. Sometimes used with GenSets requiring quick starts.

RADIATOR - a heat exchanger device that cools engine coolant water by air passing through heat-sink fins attached to coolant tubes. Consists of finned tubes that contain engine coolant. These fins act as heat sinks which transfer heat from the coolant through the tubes and fins to the air stream caused by the engine (or motor driven) pusher type fan.

REMOTE RADIATOR - a radiator not mounted on the GenSet or GenSet frame.

SHORT REMOTE RADIATOR - used on installations where either a long remote radiator is not necessary or a high remote radiator is not practical. Horizontal distance can be accommodated with the normal engine cooling system, up to the maximum external Friction Head Pressure.

SURGE TANK (Top Tank) - is an expansion tank used to accommodate the expansion of coolant water of a cooling system. The tank must be located above the engine and remote radiator. Normally used in conjunction with a remotely located engine radiator, that is mounted parallel to but not above the engine.

THERMOSTAT - a temperature sensitive device that functions to convert the effect of hot or cold temperatures to mechanical or electrical energy (e.g. an engine coolant thermostat mechanically regulates flow; a home thermostat senses the temperature and electrically regulates operation of heating or cooling systems.)

VERTICAL CORE - an optional mounting position of a remote radiator.

STANDARDS INDEX

ITEM NO.	STANDARD OR BOOKLET NO.	TITLE	AVAILABLE FROM
1	NFPA No. 30	Storage, Handling and Use of Flammable Liquids	National Fire Protection Association, 470 Atlantic Ave., Boston, MA 02210
2	NFPA No. 37	Stationary Combustion Engines and Gas Turbines	National Fire Protection Association, 470 Atlantic Ave., Boston, MA 02210
3	NFPA No. 54	National Fuel Gas Code	National Fire Protection Association, 470 Atlantic Ave., Boston, MA 02210
4	NFPA No. 70	National Electrical Code	National Fire Protection Association, 470 Atlantic Ave., Boston, MA 02210
5	NFPA No. 76A	Essential Electrical Systems For Health Care Facilities	National Fire Protection Association, 470 Atlantic Ave., Boston, MA 02210
6	NFPA No. 58	American National Standard For the Storage and Handling of Liquefied Petroleum Gases	National Fire Protection Association, 470 Atlantic Ave., Boston, MA 02210
7	NFPA No. 110	American National Standard For Emergency Standby Power Systems	National Fire Protection Association, 470 Atlantic Ave., Boston, MA 02210
8	H38.7-1972 (ASTM B241-71b)	American National Standard For Aluminum Alloy Seamless Pipe and Seamless Extruded Tube	American National Standards Institute, Inc 1430 Broadway, New York, NY 10018
9	H23.1-1970 (ASTM B-88-69)	American National Standard For Seamless Copper Water Tube	American Society For Testing and Materials 1916 Race St., Philadelphia, PA 19103
10	H23.5-1976 (ASTM B280-66A)	American National Standard For Seamless Copper Tube For Air Conditioning and Refrigeration Field Service	American National Standards Institute, Inc. 1430 Broadway, New York, NY 10018
11	ASTM A539-73	Specification for Electric Resistance Welded Coiled Steel Tubing For Gas and Fuel Oil Lines	American Society For Testing and Materials 1916 Race St., Philadelphia, PA 19103
12	B36.35-1966 (ASTM A254-64)	American National Standard For Copper Brazed Steel Tubing	American National Standards Institute, Inc. 1430 Broadway, New York, NY 10018
13	H38.3-1972 (ASTM B210-71)	American National Standard For Aluminum Alloy Drawn Seamless Tubes	American National Standards Institute, Inc. 1430 Broadway, New York, NY 10018

STANDARDS INDEX (CONTINUED)

ITEM NO.	STANDARD OR BOOKLET NO.	TITLE	AVAILABLE FROM
14	ASTM D2513-73	Specification for Thermo Plastic Gas Pressure Pipe, Tubing and Fittings	American Society For Testing and Materials 1916 Race St., Philadelphia, PA 19103
15	ASTM D2517-73	Specification For Reinforced Thermosetting Plastic Gas Pressure Pipe and Fittings	Americal Society For Testing and Materials 1916 Race St., Philadelphia, PA 19103
16	B2.1-1968	American National Standard For Pipe Threads (Except DrySeal)	American National Standards Institute, Inc. 1430 Broadway, New York, NY 10018
17	Article X	National Building Code	American Insurance Association, 85 John St., New York, NY, 10038
18	A52.1-1971	American National Standard For Chimneys, Fireplaces and Venting Systems	American National Standards Institute, Inc. 1430 Broadway, New York, NY 10018
19	Z225.1-1972 (NFPA No. 59A)	American National Standard For Production, Storage and Handling of Liquefied Natural Gas	American National Standards Institute, Inc. 1430 Broadway, New York, NY 10018
20	MSS SP-58-1963	Hangers and Supports	Manufacturer's Standardization Society of the Valve and Fitting Industry, 1815 North Fort Myer Drive Arlington, VA 22209
21		Agricultural Wiring Handbook	Food and Energy Council, 909 University Ave., Columbia, MO 65201

INSTALLATION CHECKLIST

BUYER	**INSTALLER**
Name ______________________	Name ______________________
Address ______________________	Address ______________________
______________________	______________________
Telephone ______________________	Telephone ______________________

Location of System ______________________

____

Type Installation ☐ Outdoor ☐ Indoor ☐ Roof

GenSet:	Transfer Switch:
Model No. ______________________	Model No. ______________________
Serial No. ______________________	Serial No. ______________________
OSPS:	**SPF:**
Model No. ______________________	Model No. ______________________
Serial No. ______________________	Serial No. ______________________

Line Service:	GenSet Service:
Current (Amperes) ______________________	Current (Amperes) ______________________
Phase(s)/Voltage ______________________	Phase(s)/Voltage ______________________

Alarms

Annunciators:	Telephone Dialers:
1. ______________________	1. ______________________
2. ______________________	2. ______________________
3. ______________________	3. ______________________

Optional Equipment

Tank Heater ☐ Battery Warmer ☐ Battery Charger ☐

Other (List):

____

____

General

- [ ] 1. Power plant wattage capacity is sufficient to handle maximum anticipated load.
- [ ] 2. At least 3 feet clearance (minimum is provided around the entire power plant for servicing and ventilation.)
- [ ] 3. Power plant is located in an area not subject to flooding.
- [ ] 4. Operating instructions have been conspicuously posted.
- [ ] 5. Owner(s)/operator(s) have been thoroughly briefed on system exercise requirements.
- [ ] 6. Owner(s)/operator(s) have been thoroughly briefed on correct operating and preventive maintenance procedures.

Power Plant Support

- [ ] 1. Floor, roof, earth, or other structure on which the power plant rests is strong enough and will not allow shifting or movement.
- [ ] 2. Power plant is properly supported and retained to approved base which is separate and independent of the surface on which it sits.
- [ ] 3. Supporting base is large enough - extends 12-inches all around plant.
- [ ] 4. Where power plant or supporting base rests on combustible surface, the surface area beneath plant and at least 12-inches beyond plant is covered in non-combustible insulation, with sheet metal installed between insulation and the plant or supporting base.

EXHAUST SYSTEM

- [ ] 1. Owner(s)/operator(s) thoroughly briefed on the dangers of carbon monoxide gas, preventing the buildup of this gas in inhabited areas.
- [ ] 2. Areas around plant well ventilated. No possibility of exhaust fumes entering building doors, windows, exhaust fans, or intake fans.
- [ ] 3. Exhaust gases piped safely outside and away from building.
  - [ ] a. The correct length of approved rigid pipe is connected to the power plant exhaust pipe, using approved securing methods.
  - [ ] b. The correct length of flexible metal coupling properly connected to rigid pipe, using approved securing methods.
  - [ ] c. Exhaust piping, allowing expansion and contraction, correctly supported.
  - [ ] d. Condensation drain provided in lowest section of exhaust piping.
  - [ ] e. Exhaust piping material is sufficient to withstand service.
  - [ ] f. Exhaust piping terminates outside building where hot gases or sparks are discharged harmlessly. Not directed against combustibles.
  - [ ] g. Exhaust piping insulated to guard against burning personnel.
  - [ ] h. Exhaust piping passing through walls or ceilings have approved fire proof materials and are in compliance with codes.
  - [ ] i. Exhaust piping passing into chimney extends up into the chimney beyond any other flue connection. In compliance with codes.
  - [ ] j. Exhaust piping large enough in diameter to prevent back pressure on engine.

COOLING AIR FLOW

- [ ] 1. Power plant air inlet is faced into wind where strong prevailing winds are evident.
- [ ] 2. Air inlet openings are unrestricted and are equal to 1½ times the radiator air duct area.
  - [ ] a. Cooling air exhaust opening in building is unrestricted and free air inlet area is at least as large as the air inlet area.
  - [ ] b. Louvers have been properly compensated for in cooling air inlet and exhaust openings.

GASOLINE FUEL SYSTEM

☐ 1. Check that power plant fuel tanks contain the proper fuel, non-lead, low-lead, or regular grade of gasoline per engine specifications.
☐ 2. Fuel tanks meet or exceed all Local, State or National codes.
☐ 3. Fuel lines are of copper and properly installed, supported and protected against damage.
☐ 4. Flexible fuel lines installed where required to protect against vibration, expansion, contraction, etc.
☐ 5. Fuel line shutoff valves provided to stop fuel in the event of leaks
☐ 6. Fuel line fuel pumps connected and operated to be turned On when power plant is started and turned Off when power plant is shutdown.
☐ 7. No fuel leaks are found in supply lines or engine fuel system.

Diesel Fuel System

☐ 1. Check that power plant fuel tanks contain the proper fuel, #1, #2, or a mixture of #1 and #2 diesel fuel oil per engine specifications.
☐ 2. Fuel tanks meet or exceed all Local, State or National codes.
☐ 3. Fuel lines are of copper and properly installed, supported and protected against damage.
☐ 4. Flexible fuel lines installed where required to protect against vibration, expansion, contraction, etc.
☐ 5. Fuel line shutoff valves provided to stop fuel in the event of leaks.
☐ 6. Fuel line fuel pumps connected and operated to be turned On when power plant is started and turned Off when power plant is shutdown.
☐ 7. No fuel leaks are found in supply lines or engine fuel system.

Gaseous Fuel System

☐ 1. LP Gas system connected to liquid or vapor withdrawal supply system.
☐ 2. Gaseous fuel system piping complies with all Local, State, or National codes.
☐ 3. Gaseous fuel piping has been leak tested, and properly purged prior to operation.
☐ 4. Gaseous fuel tanks, piping, and flexible piping are installed in strict compliance with Local, State, and National codes.
☐ 5. Approved gas shutoff valves are provided in gas supply lines to shutdown gaseous supply in the event of a piping line break.
☐ 6. Pressure output from gaseous fuel tanks, gas service from natural gas line service regulator is correct. Checked per local codes.

AC Power Connections

☐ 1. Wire sizes (current carrying) of all AC wiring meets with applicable codes.
☐ 2. Type of wiring insulation, wiring conduits, connection methods, and devices wiring together with conduit support methods meet applicable codes.
☐ 3. All load, line and generator connections proper and correct
☐ 4. All 120 Volts AC line connections to the engine accessories are NOT CONNECTED until after the cooling system is serviced and the batteries are installed.

DC Power Connections

- [ ] 1. All DC power or signal lines between GenSet and auxiliary equipment properly routed, supported, protected, and connected per code.
- [ ] 2. All contractor DC power or signal lines between GenSet and utility power source connected per code.

Power Plant Initial Servicing

- [ ] 1. GenSet engine properly serviced.
- [ ] 2. Batteries properly installed, serviced and charged
- [ ] 3. Battery cables installed per correct polarity (- or + grounded) per engine specification.
- [ ] 4. Cooling system (if required) properly filled with the correct mixture of anti-freeze and rust inhibitor for the environment.
- [ ] 5. Where used, coolant system engine overflow bottle filled halfway with proper mixture of anti-freeze.
- [ ] 6. Engine carburetors (Gasoline, Gaseous) properly purged.

Power Plant Pre-Start Checks

- [ ] 1. Power plant covers and shields properly installed
- [ ] 2. V-belt pulleys tension and alignment are correct.
- [ ] 3. Pre-choke and vacuum shutoff mechanisms properly adjusted.
- [ ] 4. Engine cooling and crankcase serviced properly.
- [ ] 5. Batteries properly installed, serviced and charged.
- [ ] 6. All 120 volts AC power available to operate coolant tank heater, batteries warmer, and batteries charger.
- [ ] 7. Battery heater, engine coolant tank heater, and batteries charger are operational.
- [ ] 8. All fuel and coolant shutoff valves operational.

Cranking and Running Checks

Description of Check or Test	Test Results	
	Desired	Actual
☐ 1. Carburetor, Choke, Idle, etc. functions properly.		
☐ 2. Starter cranks engine normally.		
☐ 3. Engine starts normally.		
☐ 4. Engine oil pressure normal.		
☐ 5. Coolant temperature normal.		
☐ 6. No abnormal operating noises.		
☐ 7. No leaks in fuel, oil, coolant, vacuum lines.		
☐ 8. Engine governor properly set.		
☐ 9. Voltage at full load.		
☐ 10. Frequency at full load.		
☐ 11. Current at full load.		
☐ 12. Engine coolant temperature at full load.		
☐ 13. Engine oil pressure at full load.		
☐ 14. Overspeed shutdown setting.		
☐ 15. Engine high temperature shutdown.		
☐ 16. Engine low oil pressure shutdown.		
☐ 17. GenSet or remote panel shutdown system normally, including transfer switches.		
☐ 18. Test position of transfer switches start GenSet(s) and transfer loads (Utility-to-GenSet and GenSet-to-Utility).		

Onan Corporation
Electrical Products Division
1400 73rd Avenue Northeast
Minneapolis, Minnesota 55432 U.S.A.